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EVALUATION GUIDELINES FOR SERVICE AND METHODS DEMONSTRATION PROJECTS

Carla Heaton
Chester McCall
Robert Waksman

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7. Author(s)
Carla Heaton*, Chester McCall†, Robert Waksman*

9. Performing Organization Name and Address
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Transportation Systems Center
Kendall Square
Cambridge MA 02142

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*U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge MA 02142

†CACI, Inc.
12011 San Vicente Boulevard
Los Angeles CA 90049

16. Abstract

This document consists of evaluation guidelines for planning, implementing, and reporting the findings of the evaluation of Service and Methods Demonstration (SMD) projects sponsored by the Urban Mass Transportation Administration (UMTA). The objective of these guidelines is to foster consistency of evaluation philosophy and techniques, and comparability of results so as to improve the output of the UMTA demonstration program. In addition to describing procedures for developing and executing the evaluation of SMD projects, this document contains background information on the SMD Program, a general discussion of the demonstration evaluation process, and appendixes on survey techniques and statistical methodology.

Although these guidelines were prepared specifically for use in evaluating SMD projects, their potential applicability covers the evaluation of any type of transit innovation.

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PREFACE

This document was prepared by the Office of Systems Research and Analysis, Transportation Systems Center, under the sponsorship of the Office of Service and Methods Demonstrations, Urban Mass Transportation Administration. It consists of evaluation guidelines for use by contractors responsible for evaluating Service and Methods Demonstration projects. Although these guidelines were prepared specifically for the Service and Methods Demonstration Program, PPA UM-527, their potential applicability extends beyond the evaluation of UMTA-sponsored transit demonstration projects to the evaluation of any type of transit innovation.

The contents of this document reflect comments from various reviewers on two previous draft versions as well as several months of TSC/contractor experience using the guidelines. It is anticipated that this document will be modified periodically to reflect additional experience gained in evaluating Service and Methods Demonstration projects.

The authors wish to give special acknowledgement to Peter Mengert and Mary Stearns for their extensive contributions to the statistical methodology and survey methodology appendices. In addition, the authors wish to acknowledge the valuable review comments provided by persons at UMTA, TSC, the Institute of Public Administration, the Urban Institute, and the four contractor organizations (Crain and Associates, CACI, Inc., ECI Systems, Inc., and SYSTAN, Inc.).

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OVERVIEW OF EVALUATION GUIDELINES

This manual presents guidelines for planning, implementing, and reporting the findings of the evaluation of Urban Mass Transportation Administration (UMTA) Service and Methods Demonstration (SMD) projects. These evaluation guidelines are intended for use by organizations engaged by the Transportation Systems Center (TSC) to evaluate specific projects.

The objective of these guidelines is to foster consistency of evaluation philosophy and techniques, and comparability of results so as to improve the quality and utility of information obtained from the UMTA demonstration program.

The various demonstration projects implemented under the SMD Program are meant to serve as learning tools and/or as models for other locales throughout the country. In order for these projects to have maximum effectiveness in their respective demonstration capacities, a consistent, carefully structured approach to project evaluation is desirable.

This document has been prepared to provide a common framework for developing and then executing the evaluation of individual demonstration projects. These evaluation guidelines are by no means comprehensive--that is, they do not offer a suggested or preferred course of action for every conceivable situation that might arise. Nor are they to be rigidly or blindly followed, since each demonstration and each site will be unique and will require somewhat tailor-made evaluation procedures.

It is anticipated that these quidelines will be modified during the course of the SMD Program to reflect experience gained in implementing and monitoring the evaluations of individual projects. Although it is not the desire to update these Guidelines frequently, modifications resulting from field experience will be made where appropriate for enhancement of performance and evaluation of the various projects.

In order to put these guidelines into a meaningful context, Chapter II provides background information on the UMTA Service and Methods Demonstration Program and the demonstration evaluation process. Chapters III and IV present guidelines relative to planning and executing

demonstration evaluations. Finally, Chapter V presents the recommended content and organization for each type of report to be prepared in conjunction with the evaluation process.

CHAPTER II

BACKGROUND ON THE SERVICE AND METHODS DEMONSTRATION PROGRAM AND THE EVALUATION PROCESS

A. DESCRIPTION OF THE SERVICE AND METHODS DEMONSTRATION PROGRAM

The Service and Methods Demonstration (SMD) Program being sponsored by UMTA is intended to develop, demonstrate, and evaluate new techniques and methods for using the current generation of transit equipment in providing a significantly improved quality and quantity of public transportation. UMTA's Office of Service and Methods Demonstrations intends to sponsor a number of demonstrations in various cities throughout the country. Results of the program will be disseminated in coordination with the UMTA Office of Transit Management.

Initially, the SMD Program is emphasizing five objectives:

(1) Reducing travel time for transit users
(2) Increasing transit coverage
(3) Improving the reliability of transit service
(4) Increasing transit vehicle productivity
(5) Improving service for the transit dependent.*

The demonstrations undertaken to promote one or more of these five objectives can be categorized as exemplary or experimental.

Exemplary demonstrations are designed to encourage the implementation of innovative transit services and methods on a nationwide basis by increasing public exposure to proven techniques. The emphasis in this type of demonstration is to synthesize and apply techniques which have already been developed and demonstrated to a reasonable degree on an experimental basis.

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*Transit dependent persons are those who because of age, income or physical/mental incapability must rely on public transportation, i.e., do not have use of automobiles except as passengers. Groups included as transit dependents are the elderly, handicapped, youth and poor (unemployed as well as non-members of the labor force).

In contrast, the experimental demonstrations are investigative in nature, serving to develop innovative services and methods to the stage where they are appropriate for an exemplary demonstration. As a research base for exemplary demonstrations, the experimental demonstrations focus upon addressing specific questions or providing particular services, rather than adopting the more comprehensive service philosophy of the exemplary demonstrations. Studies may investigate potential experiments and isolate the factors to be examined in limited scale demonstrations. These experimental demonstrations then become the developmental phase of new concepts.

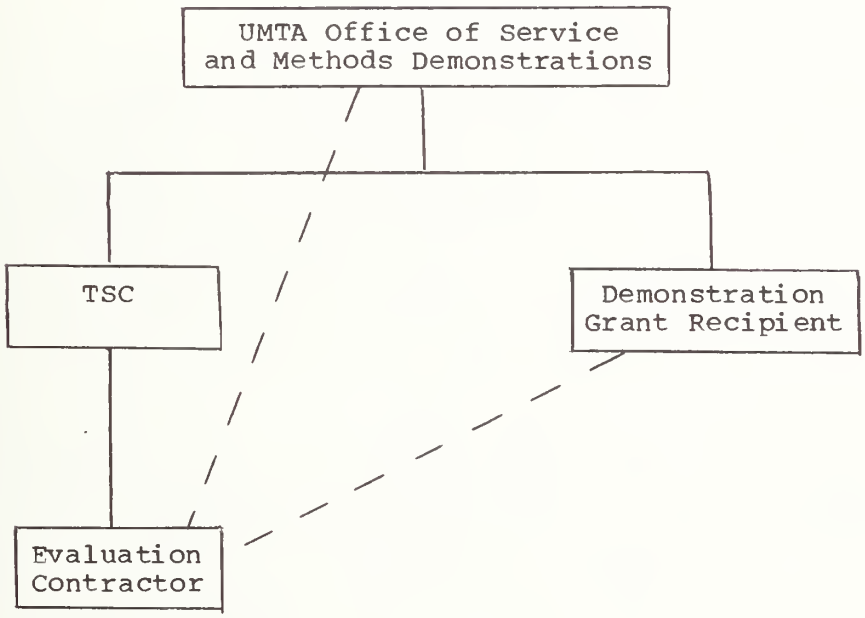
In order for the SMD Program to encourage significant transit innovations by many urban areas, the techniques demonstrated and the results obtained must be well documented and widely distributed. It is important not only that the demonstrations be structured so as to be transferrable but also that the information be disseminated in such a way that the appropriate officials in those urban areas which might benefit from the application of these techniques are made aware of their potential. Accordingly, a significant element of the SMD Program is the information dissemination function. UMTA is preparing an integrated plan for dissemination of the experience and knowledge gained from the demonstrations to a wide variety of target groups.

The exact number, general content, and location of the SMD projects are yet to be determined. For each fiscal year program, a series of primary demonstration objectives will be selected, and a group of demonstration proposals corresponding to each objective, and in keeping with total budgetary constraints, will be developed. Then, following an investigation, analysis, and negotiation process involving UMTA, TSC, and candidate sites, a final set of demonstration projects and respective sites will be agreed upon. Once final negotiation and transfer of funds between UMTA and a particular local grant recipient are completed, the demonstration can be implemented and evaluated.

As part of its responsibility to evaluate the demonstrations implemented under the SMD Program, TSC has engaged contractor support to participate in all phases of the evaluation process. Since it is anticipated that several demonstrations, which will be geographically dispersed, will be in progress simultaneously, a team of contractors has been engaged for this purpose.

Exhibit 1 shows the interaction among UMTA, TSC, the local grant recipient for a particular SMD project, and the evaluation contractor assigned to that project.

EXHIBIT 1. DEMONSTRATION ORGANIZATIONAL RELATIONSHIP



UMTA's Office of Service and Methods Demonstrations is responsible for overseeing and guiding all aspects of the demonstration, including planning, site selection, negotiations with the site, implementation, and evaluation. The local grant recipient is responsible for planning and implementing the operational phase of the demonstration project, as well as performing most of the data collection. TSC assists UMTA in the activities for which UMTA is responsible, and monitors the efforts of the evaluation contractor. Both TSC and the evaluation contractor

interface with the grant recipient (or the implementing agency, if different from the grant recipient). While being directly responsible to TSC for its activities, the evaluation contractor will maintain an informal association and relationship with both the grant recipient and the cognizant UMTA Project Manager. It is essential to recognize that the evaluation contractor performs his functions as an agent of TSC and, hence, must maintain this channel of communication and reporting.

B. OVERVIEW OF THE EVALUATION PROCESS

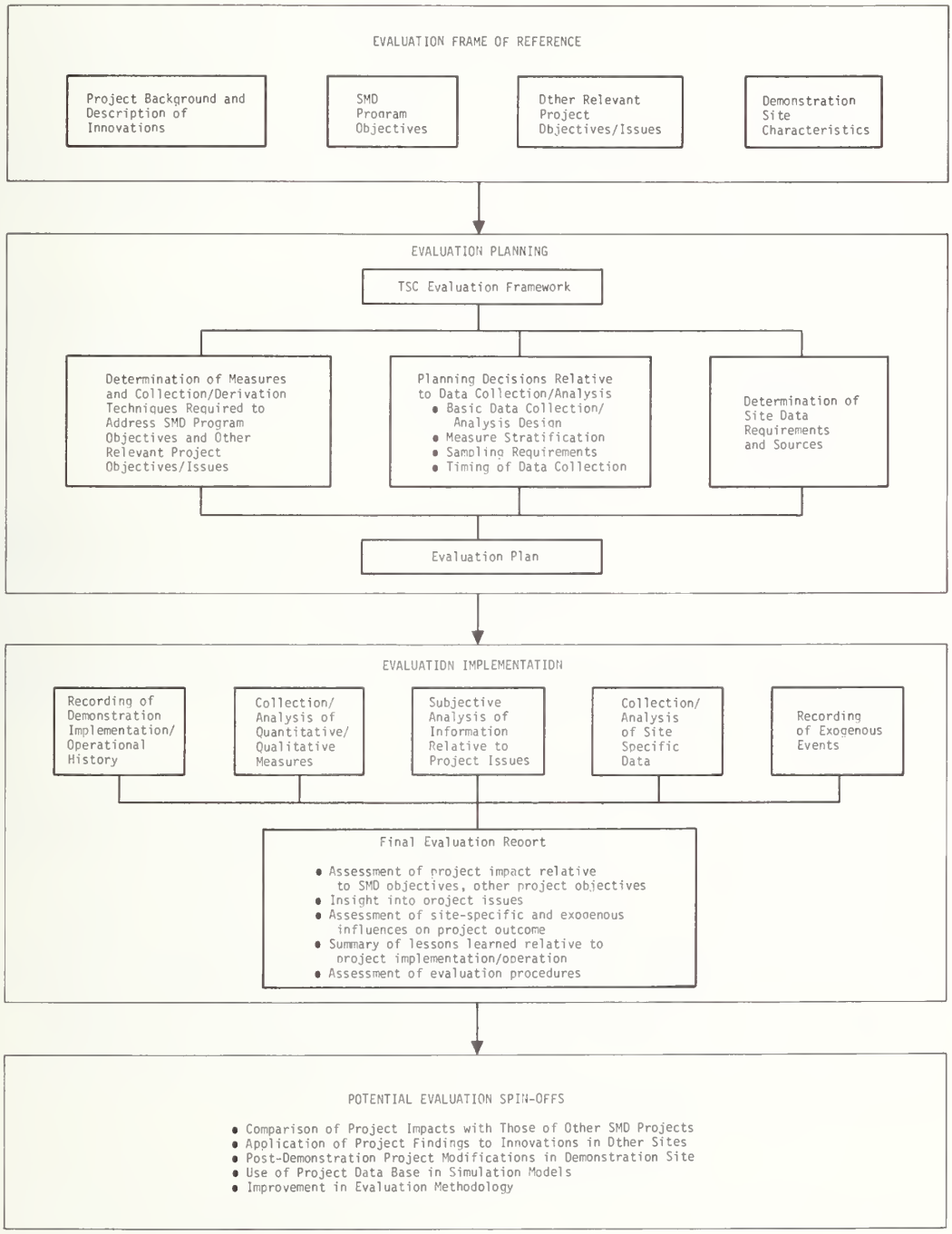
The evaluation process can be conceptually thought of as a link between the demonstration and information dissemination portions of the SMD Program. That is, it serves as a bridge between the operation of a demonstration project at a particular site and the understanding of its actual performance at that site as well as its potential effectiveness in other locales. Whether the project is exemplary or experimental, the quality of the evaluation process directly influences the accuracy and perceptiveness of the demonstration assessment and ultimately affects the applicability and transferability of project findings.

Exhibit 2 is a flow diagram representing the evaluation process for an SMD project. The diagram is divided into four major sections: the evaluation frame of reference, evaluation planning, evaluation implementation, and potential evaluation spin-offs. (The specific organizational responsibilities associated with the various aspects of each SMD project are given in Exhibit 4 later in this chapter.) The first and fourth sections can be thought of, respectively, as input to and output from the active phase of the evaluation process, planning and implementation. A discussion of each of the four sections follows.

1. Evaluation Frame of Reference

The evaluation frame of reference consists of four "given" elements for an evaluation: the demonstration project, SMD Program objectives, other relevant project objectives/issues, and the demonstration site.

EXHIBIT 2. DEMONSTRATION EVALUATION PROCESS



Typically, an SMD project consists of some combination of service-related and/or methods-related transit innovations which are introduced simultaneously or in sequence. Exhibit 3 presents examples of innovations which might be included in SMD projects. This is not meant to be an exhaustive list, but rather serves as an indication of the range of services and techniques which might be applied.

The project is classified as exemplary or experimental depending on how innovative the various components are and on the envisioned function of the project-- showcase for other cities to emulate vs. testing ground for unproven techniques.

Each SMD project (or individual elements thereof) is intended to serve one or more SMD program objectives. The five initial program objectives deal with user-related improvements (travel time, coverage, reliability), operator-related improvements (productivity), and service improvements for a special market segment, the transit dependent.

For any given project, there will be objectives, over and above the addressed SMD Program objectives, which should be considered in the evaluation. These might be objectives which the locality is striving to attain (for example, a certain percentage reduction in vehicle travel or downtown parking requirements) or objectives which, while not specifically transit-oriented, certainly have both a local and national bearing (examples of which are pollution reduction and energy conservation).

The relevant SMD, local, and national objectives describe the desired or anticipated impact of the project on the transit user, operator, and general community. In addition to these objectives, there will generally be a set of issues, or research questions, associated with a demonstration project. These might concern operational aspects of the project innovations (e.g., safety, ease of implementation, public acceptance) or might be of an exploratory nature (e.g., assessing passenger sensitivity to transfers). It is anticipated that experimental demonstrations will be more issue-oriented than exemplary demonstrations, owing to the many more unknowns regarding operational feasibility and characteristics of the demonstrated services or methods.

EXHIBIT 3

TYPICAL SERVICE AND METHODS DEMONSTRATION
PROGRAM PROJECT INNOVATIONS

CATEGORY OF INNOVATION	EXAMPLES
Service Additions/Expansions	Fixed route, demand responsive, subscription buses and vans, para-transit, shared taxi, multi-user auto system, jitney, light/heavy rail service, shared ride auto.
Service Improvements	Increased service frequency, improved coordination at transfer points, park-and-ride lots.
New Types of Buses	Small buses, Transbus, double deck bus, articulated bus, special bus for wheelchair-confined passengers, electric buses.
Operational Improvements	Manual/automatic vehicle monitoring, surveillance, command and control systems.
Preferential Treatment of Buses/Carpools	Exclusive/reserved lanes (with-flow or contraflow), ramp metering, priority traffic signalization systems, bus-only streets, auto restricted zones.
Pricing/Fare Collection Policies	No fare, off-peak fare reductions, special fares for the elderly, congestion pricing, credit card billing, prepaid passes, tokens.
Institutional Changes	Parking restrictions, auto restricted zones, staggered work hours, transit/carpool marketing programs.

The demonstration site can consist of anything from a portion of a city to a group of cities or towns, and can be at any point along the population and density spectrum. An understanding of the unique demographic, economic, geographic, and transportation characteristics of the site, as well as prevailing attitudes toward transportation, is a useful and necessary adjunct to knowledge about the demonstration project elements and objectives.

The planned innovations, project objectives and issues, and site characteristics will generally be available from the demonstration grant application submitted to UMTA by the site prior to approval of the project. Depending on the timing of the contractor's initial involvement in the project, a more detailed description of the project may be available in the form of a Project Implementation Plan. Further background on the demonstration -- e.g., genesis of the project concept, recent history of transit/para-transit developments at the site -- can be obtained through discussions with the UMTA Project Manager, TSC staff, and the grantee.

2. Evaluation Planning

The evaluation planning phase of the demonstration evaluation process is the period during which the contractor interacts with UMTA, TSC, and various agencies at the local level to transform the evaluation frame of reference into a detailed, structured program for conducting the evaluation. This phase sets the stage for the entire evaluation effort and in addition provides an opportunity to reassess and, if necessary, restructure the planned demonstration project.

The planning phase begins with TSC's preparation of an Evaluation Framework for the particular project, which describes:

(1) Pertinent information on the project and site (in particular, an indication of what features of the demonstration are unique and merit emphasis in the evaluation).

(2) SMD Program objectives addressed by the demonstration.

(3) Relevant local and/or national objectives addressed (and the relative emphasis to be placed on these objectives vs. SMD objectives).

(4) Key issues to be addressed.

(5) Recommended scope and focus of the evaluation..

It should be noted that the contents of each Evaluation Framework will vary from demonstration to demonstration, depending on the nature and timing of the project.

The Evaluation Framework becomes the basis for the more detailed Evaluation Plan* which is developed by the contractor. While TSC will provide a general evaluation approach and may suggest some measures to be collected, it is really left to the contractor to refine and elaborate on TSC's suggested approach by developing specific procedures for collecting and analyzing data relative to project objectives, issues, and the site.

In developing the Evaluation Plan, the contractor is encouraged to propose changes to the approach recommended by TSC in its Evaluation Framework, particularly if the proposed modifications have significant potential to improve the objectivity, accuracy, completeness, and/or efficiency of the project evaluation effort or to enhance the transferrability of project findings. In addition, total evaluation costs relative to potential findings must be borne in mind at all times. Throughout the process of developing the Evaluation Plan, the contractor is urged to keep in close contact with the local agency responsible for implementing and operating the demonstration and performing data collection. This continuing liaison with the UMTA grant recipient will ensure that the proposed methods of data collection are consistent with the resources available at the local level, with the demonstration implementation plan developed by the site, and with reasonable costs for the evaluation contractor efforts.

As is apparent from the preceding discussion, the evaluation planning phase entails substantial and continued interaction among all parties involved in the demonstration project. Ideally, planning of the evaluation effort should be coordinated with, and take place concurrently with, planning of the project itself. This coordination between

*Chapter III presents guidelines relative to the evaluation planning phase. The recommended content and organization of the Evaluation Plan are presented in Chapter V.

the implementation/operation and evaluation planning cycles permits optimum flexibility in the conduct of the overall demonstration project. If necessary, operational aspects of the demonstration can be planned to conform to requirements of the evaluation, rather than the evaluation having to be integrated into a pre-existing, rigid operational structure. The concurrence of the two planning cycles ensures that the Evaluation Plan is completed prior to the implementation of the project. Early development of the Plan, in turn, allows the necessary lead time for "before" data collection -- that is, observations of transit system performance prior to the introduction of the transit innovation(s) as well as possible information on community awareness and attitudes prior to project implementation. Throughout this phase of the project, it is critical to recognize that the UMTA Project Manager has the final say with respect to any modifications in the project itself as well as the elements of the evaluation plan.

3. Evaluation Implementation

The evaluation implementation phase is the period during which the approved Evaluation Plan is executed. Activities during this phase include collection/analysis of data relative to project objectives and issues, collection/analysis of data on site characteristics, compilation of a chronology describing the implementation and operation of the demonstration, and recording of exogenous factors which might influence demonstration findings. Contractor functions during this phase include monitoring of the data collection process (generally to be performed by the local grant recipient), any data collection not performed by the grant recipient, data reduction and analysis, subjective analysis of information relative to project issues, and synthesis of project findings into one or more Interim Evaluation Reports and a Final Evaluation Report.*

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*Chapter IV presents guidelines relative to the evaluation implementation phase. Chapter V gives the recommended content and organization of the various contractor reports prepared during this phase, including the Monthly Evaluation Progress Report, the Annual Project Status Summary, the Interim Evaluation Report, and the Final Evaluation Report. In addition, Chapter V describes the content of the grantee's Quarterly Project Progress Report to UMTA, which can serve as useful input to the contractor's work.

This phase not only generates information on which the final assessment of the project is based but also provides feedback information relative to ongoing project operations. The ongoing evaluation activities, while adding to the cumulative body of quantitative and qualitative information regarding the project's impacts, provide interim indications of how the various innovations are functioning and the preliminary effects of these innovations on such areas as patronage, travel time, and rider attitudes. These interim findings serve as useful input to the local agency responsible for implementing and operating the demonstration, by suggesting the need for operational modifications. For example, in a project involving a sequence of planned innovations (say, experimentation with fares or service frequencies), the finding that ridership levels have stabilized sooner than anticipated would make it possible to expand the list of experimental options being implemented.

During this phase, modifications may be made to the evaluation procedures originally specified in the Evaluation Plan. For instance, examination of interim findings may reveal certain gaps or redundancies in the originally planned data collection program. Still other reasons for modifying the evaluation procedure might be operational changes in the project, unanticipated developments in the site, or discovery of an improved evaluation procedure. Procedural steps to accomplish this necessary update for the Evaluation Plan appear in Chapter V.

The culmination of the evaluation implementation phase is the Final Evaluation Report, which presents the following types of findings:

(1) Assessment of the project in terms of its attainment of relevant SMD Program objectives and other (local and/or national) project objectives.

(2) Insight into project issues associated with operational feasibility and characteristics of the demonstrated innovations.

(3) Assessment of the influence of site-specific characteristics and exogenous factors on the outcome of the demonstration.

(4) Lessons learned, based on practical experience, relative to the implementation and operation of the demonstrated innovations (possibly to include recommendations for project modifications in the

demonstration site or for future applications in other locales).

(5) Assessment of the evaluation procedures employed in terms of cost, accuracy, etc.

In essence, the Final Report presents an assessment of the impact of the innovations at the site and provides guidance for their transfer to other locales.

The Final Evaluation Report relies on both narrative and graphic exposition, with detailed quantitative data and documentation of procedures relegated to technical appendices. Since the report is intended for a variety of audiences -- including transportation planners, transit operators, and federal, state, and local officials -- it contains an Executive Summary which highlights the salient project findings.

4. Potential Evaluation Spin-offs

It is anticipated that each demonstration will give rise to potential implementation and analytical spinoffs. The Final Evaluation Report, while essentially documenting the history and effects of a single case study project, also serves the broader function of increasing the understanding of and stimulating the application of the demonstrated services and/or methods in other localities. Information presented in the report provides a versatile basis for comparing the effects of the particular demonstration with those of other similar projects, suggesting modifications to the demonstrated services/methods for future application, and predicting the effectiveness and applicability of the demonstrated services/ methods in other cities. Moreover, the report's assessment of project evaluation procedures can serve as a stimulus for improving the state-of-the-art of evaluation techniques. Since these broader functions of the Final Evaluation Report generally materialize after the demonstration period and are not within the purview of the evaluation contractor assigned to a particular project, they are shown in Exhibit 2 as potential evaluation spin-offs.

C. COORDINATION OF SMD EVALUATIONS

Exhibit 4 summarizes the various activities involved in planning, implementing, and evaluating an SMD project and indicates the allocation of responsibility for these activities. The sequence of activities ranges from overall SMD Program definition, to the operation and evaluation of an individual demonstration, to the spin-off uses of the project. It can be seen that the entire stream of activites, especially those comprising the evaluation process, involves extensive interaction among UMTA, the grant recipient, TSC, and the evaluation contractor. Moreover, it should be noted that the activities shown do not always occur in a fixed sequence. Time constraints may require that some of the steps be performed in parallel, and there will generally be considerable interaction and feedback between the project planning and evaluation planning phases. Evaluation spin-offs, while arising out of individual demonstrations, will result in activities which extend beyond the UMTA, TSC, grantee, and evaluator organizations.

The diversity of activities and generally long (two to three year) time frame for an individual project necessitate close and continual coordination among the groups involved. However, equally as important as coordination within a particular project is coordination across demonstration projects, so as to maximize the effectiveness of the SMD Program in encouraging the demonstration and application of new services and methods. This coordination across projects is especially important with respect to the evaluation process. Given the multiplicity of sites, demonstrations, and participating organizations within the SMD Program, there is a strong need for coordination of the demonstration evaluation process so as to achieve consistency in the planning, implementation, and output of individual project evaluations.

With respect to the conduct of the evaluations, such coordination will ensure that: (1) the scope of each evaluation effort is consistent with the importance of that particular demonstration project relative to other SMD projects; and (2) the technical approaches used to evaluate projects are consistent with the current state-of-the-art of evaluation techniques.

With respect to evaluation output, such coordination will ensure that the Final Evaluation Reports associated with individual projects are consistent in terms of content, format, perspective, and level of detail, thereby facilitating their synthesis into an Annual Service and

EXHIBIT 4
SMD PROJECT PLANNING/IMPLEMENTATION/EVALUATION: SEQUENCE OF AND RESPONSIBILITY FOR ACTIVITIES

Category of Activity	Activity	Responsibility for Activities			
		UMTA	Grant Recipient	TSC	Evaluation Contractor
SMD Program	Establishment of SMD Program objectives	P		S	
SMD Program	Identification of candidate sites/demonstrations	P		S	
Demo-operation	UMTA/Site negotiations	P	P		
Demo-operation	Development of final demonstration description and implementation plan	R	P	R	
Demo-evaluation	Development of Evaluation Framework	R	R	P	
Demo-evaluation	Development of Evaluation Plan	R	R	M	P
Demo-evaluation	"Before" data collection		P		M
Demo-operation	Demonstration implementation	M	P	M	M
Demo-evaluation	Data collection		P		M
Demo-evaluation	Data reduction and analysis			M	P
Demo-oper/eval	Preparation of Quarterly Project Progress Reports	R	P		
Demo-evaluation	Preparation of Monthly Evaluation Progress Reports	R		R	P
Demo-evaluation	Preparation of Annual Project Status Summaries	R	R	R	P
Demo-evaluation	Preparation of Interim Evaluation Report(s)	R	R	R	P
Demo-evaluation	Preparation of Final Evaluation Report	R	R	R	P
Evaluation Spin-off	Inter-project comparisons	R		P	
Evaluation Spin-off	Post-demonstration project modifications at site	R	P		
Evaluation Spin-off	Improvement in evaluation methodology	R		R	P
Evaluation Spin-off	Application of project findings to innovations in other sites	Other sites			
Evaluation Spin-off	Use of project data base in simulation models	• Transportation planners			

P = primary role
M = monitoring role
R = review function

Methods Demonstration Program Report. This consistency in output will, in addition, enhance the spin-off potential of the evaluations. The achievement of a basic data set of uniform quality across demonstrations will make possible interproject comparisons in terms of system user charateristics, site characteristics, and system performance and financial measures. These types of comparisons will be especially significant in the case of multiple applications of a particular service or method in several locations, or in the case of demonstrations involving alternative services or methods directed towards a particular SMD Program objective.

The coordination of the individual evaluation efforts will be achieved through TSC's active and continual participation in the program, with functions ranging from initial planning of each project evaluation effort (the Evaluation Framework), to monitoring of the contractor team, and finally to synthesis of individual demonstrations, evaluation reports and results into an annual SMD report. This guidelines document constitutes the first stage of TSC's evaluation coordination function, in that it describes general procedures to be followed by each contractor in performing the various evaluation tasks specified in the contract.

CHAPTER III

GUIDELINES FOR PLANNING EVALUATION ACTIVITIES

This chapter presents specific guidelines for planning the evaluation activities associated with a particular SMD project. As was mentioned in Chapter II, the evaluation planning phase of the demonstration evaluation process is that period during which the contractor prepares a detailed Evaluation Plan based on TSC's Evaluation Framework. The Evaluation Plan contains, among other things, a listing of relevant quantitative and qualitative measures related to various SMD, local, and national objectives and relevant issues, associated data collection and analysis procedures, and site specific data requirements and sources (both one-time and recurring). As such, this plan constitutes a structured, time-phased program for subsequently conducting the evaluation.

The chapter is organized into three sections, corresponding to the basic decision-making elements shown in Exhibit 2:

- Determination of site data requirements and sources
- Determination of measures and collection/derivation techniques required to address SMD Program objectives and other relevant objectives/issues
- Planning considerations relative to data collection and analysis.

The organization of the chapter is not meant to imply a highly ordered time-sequencing of activities, since the evaluation planning phase is in fact highly iterative and dynamic. Moreover, it is important to realize that these guidelines comprise a basic set of ground rules for planning evaluations. The evaluation contractor will, in all probability, need to depart from these guidelines during the actual planning phase, so as to conform to the unique conditions surrounding a given demonstration.

The contractor should recognize his responsibility in working with the grantee and TSC to assure that an objective assessment of the project is achieved. One or more site visits during the evaluation planning phase is desirable to establish working relationships and channels of communication among the various involved organizations and to uncover any constraints which may have a significant

bearing on the development of the Evaluation Plan. During this planning effort, clarification must be made regarding responsibilities for performing and/or overseeing various activities. The Evaluation Plan should indicate the finally agreed upon allocation of responsibility between the contractor and local organizations.

A. DETERMINATION OF SITE DATA REQUIREMENTS AND SOURCES

The purpose of the site data is to provide an in-depth understanding of those characteristics of the site which might in some way influence the outcome of the project or the interpretation of project results. Obviously, the SMD project will not be implemented in a static environment, but rather it will affect the surrounding area. Thus an examination of certain site characteristics is necessary in order to assess fully and accurately the impact of the project.

An additional function of site data is to enhance the comparability and transferability of SMD project findings. Specifically, if conclusions drawn from one project are to be compared with findings of other similar projects or "transferred" to other potential sites, there must exist an objective approach for such a comparison or transfer. This requires the identification of a set of site-specific measures which permit one to classify sites in terms of meaningful similarities, or to identify significant areas in which sites differ, such as socio-economic characteristics. Institutional groups which must decide how to allocate their available funds for transportation system improvement need to be able to compare their site environment with that of demonstration sites.

Examples of site data which might be relevant are demographic and land use characteristics, transportation facilities, and vehicle travel characteristics, both intra- and inter-urban. In addition, information on the political/institutional climate of the area and prevailing attitudes toward transportation-related issues might be helpful in anticipating or understanding any problems regarding implementation and evaluation of the project.

A review of recent demonstration projects indicates an inconsistency in both amounts of and details for reported site-specific data. To some extent this inconsistency reflects a lack of standardized site data requirements, but more significantly it reflects deficiencies in knowledge

regarding the interplay between site characteristics and demonstration results. In an attempt to shed further light on the subject, a basic set of data requirements has been developed for use in SMD projects (see Exhibit 5).

Contractors are encouraged to propose additions or deletions to this list, in the context of particular projects, if it is felt that the nature and scope of the project call for a wider or narrower set of site descriptors. If the project is relatively self-contained (e.g., a demonstration of a new vehicle concept), then site data collection need not encompass broad site descriptors such as demographic and land use characteristics; on the other hand, a far-ranging project (e.g., introduction of a coordinated feeder/line-haul/distribution service) probably calls for the complete gamut of site data so as to understand user/non-user characteristics, modal shift, and integration of the new service into the existing transportation infrastructure. Contractors are also encouraged to propose permanent additions, deletions, or changes to this minimum list based on their cumulative experience in conducting SMD evaluations.

Aside from the site data requirements in Exhibit 5, it may be desirable to collect a standardized set of attitudinal measures to obtain a profile of the community. Examples would be general opinions regarding the role of government, environmental issues, adequacy of transportation facilities, and desirability of travel by alternative modes. Since the value of this type of data for demonstration evaluation and transferability purposes has not yet been fully explored, community profile data will be collected only in selected demonstrations (to be identified by TSC in the Evaluation Framework). Appendix A contains sample questionnaires which might be used to obtain such data. As experience is gained in this area, a standardized approach to developing an attitudinal profile of the demonstration site may be formally incorporated into these guidelines.

It is anticipated that the data set and descriptive information shown in Exhibit 5 will be available from secondary sources or from the grantee and will not involve specialized data collection activities (an exception being attitudinal profile data, which will entail surveys). Exhibit 6 indicates typical sources for various categories of site-specific data.

Once the contractor has determined the type of site data to be assembled and the appropriate sources, two decisions remain: (1) the geographic scope of the area for

EXHIBIT 5. BASIC SITE DATA REQUIREMENTS FOR SMD PROJECTS

1. Population
2. Square miles
3. Population density, persons per square mile
4. Number of persons in the labor force
5. Number of households, by type *
6. Age, sex, education, occupation, income distributions *
7. Household auto ownership *
8. Number of persons with no drivers license
9. Modal split, by trip purpose or time of day if available
10. Existing (Pre-demonstration) transit service characteristics
    - Route miles (fixed route systems)
    - Tour area (non-fixed route systems)
    - In-service vehicles per square mile of service area (non-fixed route systems)
    - In-service vehicles per hour within service area
    - Time of service operation throughout day
    - Days of service operation throughout year
    - Service frequency (fixed route systems)
    - Fare schedule
11. Description of para-transit service characteristics
    - Data on taxi operations
    - Information on carpool promotion/matching programs

Map of the site showing:

- The SMD project service area-- note that this might be a contiguous area served throughout by the SMD transit system, or it might be two or more non-contiguous areas linked by the SMD service through a travel corridor
- The existing transportation network-- major highways, transit lines, commuter rail lines
- Major topographical features such as rivers
- The central business district
- Any other important activity centers

Description of relevant site features such as:

- Weather conditions
- Seasonal population variations
- Institutional/political climate
- Economic conditions
- Cost indices-- e.g., cost of living index, prevailing transit wage rates
- Population/employment growth rate, land use development patterns
- Residential mobility

* See Appendix A for a discussion of recommended stratifications for these variables.

EXHIBIT 6. TYPICAL SOURCES FOR SITE DATA*

Data Needed	Typical Sources
Demographic	U.S. Bureau of the Census City or County Clerk State Department of Labor State Department of Internal Revenue City or County Planning Board
Motor Vehicle Travel	State Highway Department (or State DOT) U.S. Census (Journey-to-Work) Local Traffic Department Earlier Travel Surveys State Registration Records Gasoline Tax Collection Records
Mass Transportation Travel	Local Transit Companies Regional Transit Authority State Highway Department (or State DOT) Local Planning Agency U.S. Census (Journey-to-Work) Earlier Travel Surveys
Travel by Intercity Modes (air, rail, bus)	Federal Agencies such as: Civil Aeronautics Board Federal Aviation Administration Interstate Commerce Commission Federal Railroad Administration Department of Commerce State Regulatory Agencies Earlier Travel Surveys Private Carriers
Land Use Characteristics	City Directories Local, Regional and State Planning Agencies Tax Assessor's Records Planning Studies

* Source: Federal Highway Administration with Urban Mass Transportation Administration, Urban Mass Transportation Travel Surveys, Washington, D.C., August, 1972.

Note: In order to ensure the consistency of site data across sites, federally-sponsored data bases (e.g., U.S. Census) should be used wherever possible.

which data is to be assembled, and (2) the time period(s) for which data is to be assembled.

Regarding the geographic scope, it was indicated above that a basic data set should be assembled for the SMD service area.* In some cases, data conforming exactly to the service area boundary may be unavailable or may be obtained only by aggregation of fine-grained (e.g., Census tract) data. If there is available data for an area approximating the service area, the contractor may choose to use this pre-existing data base rather than deriving a special data base, provided that such a substitution will not be misleading and bias the evaluation. On the other hand, the use of fine-grained data may be appropriate if the service area is large and heterogeneous and thus should be divided into zones.

The time period(s) for which data is to be assembled depends on the time period of the demonstration project and the rate at which conditions at the site are changing. If the project spans a fairly long period it may be desirable to gather site data for periods before, during, and after the project. In the case of a rapidly changing area or a staged project, data for even more points in time may be necessary. Moreover, if an historical perspective on the site is deemed relevant to the evaluation, it may be desirable to obtain 1960 as well as 1970 Census figures or recent trend data for key variables such as population, employment, and modal split. Since original data collection by the contractor is not anticipated, the number and exact timing of site data periods will be constrained by the collection cycles of existing sources.

B. DETERMINATION OF MEASURES AND COLLECTION/DERIVATION TECHNIQUES REQUIRED TO ADDRESS SMD PROGRAM OBJECTIVES AND OTHER RELEVANT PROJECT OBJECTIVES/ISSUES

It was pointed out in Chapter II that TSC's Evaluation Framework will set forth a recommended set of SMD Program

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*A definition of the SMD service area may not be available at the outset of the project, but rather will need to be developed during the evaluation implementation phase on the basis of user surveys.

objectives, relevant project objectives (of local and national significance), and project issues to be examined. The contractor, in developing the Evaluation Plan, is responsible for reviewing this recommended set in the context of the grantee's Project Implementation Plan and the various national and local perspectives, and then proposing appropriate modifications to the list of objectives and issues.

Once the set of project objectives and issues has been finalized (which involves obtaining verbal concurrence from TSC), the contractor must associate with these items a set of germane measures and identify suitable techniques for collecting or deriving each measure. It is important to note that certain issues may not lend themselves to the collection of either qualitative or quantitative measures but may rather involve subjective analysis of pertinent information.

The material presented below is intended to guide the contractor in developing appropriate measures and associated collection/derivation techniques. It is important to recognize that this material will undoubtedly be modified as information is gained through the consistent application and analysis of evaluation techniques on the SMD projects. Therefore, because revisions to data program requirements in terms of basic data sets, collection and analysis procedures, and presentation techniques can be expected, the fundamental value of this section of the guidelines lies in the manner in which it structures the approach to the selection of measures and the selection of techniques for collecting/deriving them.

In preparing this material, considerable documentation was reviewed (see Bibliography). In addition, direct observance and participation in many previous and ongoing demonstration projects has permitted those preparing this document to identify not only a logical structure for project evaluation but also to highlight problem areas of which all potential project evaluators should be aware. The specific demonstration projects which contributed the greatest amount of insight were the Minneapolis Urban Corridor Project, Miami I-95/N.W. 7th Avenue Bus/Car Pool Project, Seattle Blue Streak Project, and Shirley Highway Express-Bus-On-Freeway Project.

1. Basic Set of Measures

Exhibit 7 presents a basic set of measures applicable for evaluating SMD demonstrations. The exhibit is divided into six sections: the first five contain measures corresponding to the five SMD Program objectives, and the last section consists of measures related to other project objectives and issues. For each measure (listed in column 1), the following information is indicated:

- Type of measure (column 2)

  Quantitative -- a measure which is expressed in terms of counts, measurements, dollars, or other physical units

  Qualitative -- a measure which is expressed in terms of people's attitudes, perceptions, or observations

- Method of obtaining measure (column 3)

  Collected -- obtained by measurement (vehicle travel time), counting (number of passengers), surveying (perceived reliability), or from records (daily revenue)

  Derived -- calculated from collected measures either by simple arithmetic procedures (passenger miles per seat mile) or through use of analytic models (reduction in air pollution or fuel consumption)

- Possible collection/derivation techniques (column 4)

  Brief description of alternative methods for collecting or deriving measure

In reviewing the basic set of measures in Exhibit 7, it is important to note that some of these measures would be more meaningful if stratified by time of day (peak versus off-peak), location (corridor versus arterial), person time segments (waiting, access, transfer, in-vehicle), route type (fixed route versus demand responsive), and vehicle tour segments (in-service, non-service). Because such a classification of measures would have needlessly extended the list in Exhibit 7, the subject of stratification, or categorization, with respect to specific data collection

EXHIBIT 7. A SET OF BASIC MEASURES AND COLLECTION/DERIVATION TECHNIQUES FOR SMD PROJECTS

Measures: I. Travel Time	Type of Measure*	Collected or Derived	Possible Collection/Derivation Techniques
1.1 Actual person transit trip time in minutes	Qt.	C	Observers at appropriate access/ egress points or trip segments
1.2 Perceived person transit trip time in minutes	Ql.	C	Surveys.
1.3 Actual person auto trip time in minutes	Qt.	C	Floating car on arterials and freeways with observers to record travel time using stop watches. Observers at points along route.
1.4 Perceived person auto trip time in minutes	Ql.	C	Surveys.
1.5 Ratio of transit trip time to auto trip time	Qt./Ql.	D	1.1 divided by 1.3 (for comparable trip), or 1.2 divided by 1.4.
1.6 Actual transit vehicle in-service travel time in minutes	Qt.	C	Driver schedules; on-board checkers; vehicle monitoring devices; tape recorders.
1.7 Transit vehicle non-service travel time in minutes	Qt.	C	Driver schedules; on-board checkers; vehicle monitoring devices; tape recorders.
1.8 Scheduled transit vehicle in-service travel time in minutes	Qt.	C	Transit schedules.
* Qt. = quantitative; Ql. = qualitative.			

EXHIB. 7 (CONT)

Measures: I. Travel Time	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
1.9 Transit vehicle speed in miles per hour	Qt.	C	Test car with the use of a digital tape recorder; real-time surveillance system.
1.10 Automobile speed in miles per hour	Qt.	C	Test car with the use of a digital tape recorder, real-time surveillance system.

EXHIB. 7 (CONT)

Measures: II. Coverage	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
2.1 Service area in square miles	Qt.	C	Project description, or obtained from observed travel patterns or origin-destination data in surveys.
2.2 Route miles (fixed route systems)	Qt.	C	Transit records.
2.3 Tour area (non-fixed route systems)	Qt.	C	Transit records.
2.4 Route miles per square mile of service area (fixed route systems)	Qt.	D	2.2 divided by 2.1.
2.5 Vehicles per square mile of service area (non-fixed route systems)	Qt.	D	4.1 divided by 2.1.
2.6 Service frequency (fixed route systems)	Qt.	C	Real-time surveillance system; on-street observer; transit records.
2.7 Vehicle in-service hours per hour within service area	Qt.	D	(4.7 x 4.12) divided by hours of operation (2.8).
2.8 Time of service operation throughout the day	Qt.	C	Transit records.
2.9 Days of service operation throughout the year	Qt.	C	Transit records.
2.10 Directness of system routing (Percentage of person trips requiring no transfers)	Qt.	C	Surveys; obtained from schedules and hypothetical origin-destination patterns.

EXHIB. 7 (CONT)

Measures: II. Coverage	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
2.11 Fare structure	Qt.	C	Transit records.
2.12 Number of park-and-ride spaces (where applicable)	Qt.	C	Transit records.
2.13 System seat availability	Qt.	C	On-street observers; surveys.
2.14 Number of person trips in a given time period that could be made using the SMD service	Qt.	C	Surveys.
2.15 Number of person trips in a given time period actually made using SMD Service	Qt.	C	Surveys.
2.16 SMD service market share	Qt.	D	2.15 divided by 2.14.
2.17 Service area target population (number of persons who could use SMD service)	Qt.	C	Census/local data; surveys.
2.18 Target population density	Qt.	D	2.17 divided by 2.1.
2.19 Number of persons who actually use, or subscribe to, SMD service	Qt.	C	Surveys in service areas; registration records, if applicable.
2.20 Percent of target population using SMD service	Qt.	D	2.19 divided by 2.17.
2.21 Percent of service area trips diverted to SMD service from auto and other transit/paratransit modes	Qt.	C	Surveys.

EXHIB. 7 (CONT)

Measures: II. Coverage	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
2.22 Person distances in miles to system access points	Qt.	C	Measurements based on site maps; surveys.
2.23 User access/egress modal split (sub-modal split)	Qt.	C	Surveys.
2.24 Trip production rates (by mode, purpose, etc.)	Qt.	C	Surveys.
2.25 User/non-user demographic characteristics	Qt.	C	Surveys.
2.26 User/non-user attitudes towards SMD service; e.g., reasons for use/non-use; perceived comfort, convenience, accessibility; relative importance of various service attributes.	Ql.	C	Surveys.

EXHIB. 7 (CONT)

Measures: III. Reliability	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
3.1 Variability of transit trip time	Qt.	D	Standard deviation of actual transit trip time divided by average actual transit trip time.
3.2 Difference between scheduled and actual transit trip time in minutes (fixed route systems)	Qt.	D	1.6 minus 1.8.
3.3 Difference between scheduled and actual vehicle arrival time at access points (fixed route systems)	Qt.	D	(Actual arrival time noted by on-board or on-street observers) minus (scheduled arrival time from schedules).
3.4 Difference between promised and actual vehicle arrival time at pick-up points (non-fixed route systems)	Qt.	D	(Actual arrival time from driver log) minus (scheduled arrival time from dispatcher log).
3.5 Difference between scheduled and actual transit headway (fixed route systems)	Qt.	D	(Actual time between vehicles noted by on-street observer or surveillance system) minus (scheduled interval from schedules)
3.6 Operating time between failures, in minutes, for transit vehicles	Qt.	C	Transit records.
3.7 Operating time between failures, in minutes, for support equipment	Qt.	C	Transit records.
3.8 Vehicle delay in minutes due to breakdown	Qt.	C	Transit records.

EXHIB. 7 (CONT)

Measures: III. Reliability	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
3.9 Percent of vehicle time in scheduled and non-scheduled maintenance	Qt.	D	(Time in scheduled maintenance) divided by (time in repair). (NOTE: Both items from transit records).
3.10 Time to repair transit vehicles, in minutes	Qt.	C	Transit records.
3.11 Time to repair support equipment, in minutes	Qt.	C	Transit records.
3.12 Number of transit and non-transit accidents per unit of time	Qt.	C	Transit and police records; surveillance system.
3.13 Perceived reliability of SMD service to users (i.e., to get to destination on time)	Ql.	C	Surveys.

EXHIB. 7 (CONT)

Measures: IV. Productivity	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
4.1 Number of vehicles by type	Qt.	C	Transit records.
4.2 Seated vehicle capacity	Qt.	C	Transit records.
4.3 Standing vehicle capacity	Qt.	C	Transit records.
4.4 Number of vehicle trips per day by route (fixed route systems)	Qt.	C	Transit records.
4.5 Number of vehicle miles per day	Qt.	C	Transit records.
4.6 Number of seat miles per day	Qt.	C	Transit records.
4.7 Number of vehicle hours per day (i.e., number of driver hours)	Qt.	C	Transit records.
4.8 Number of other operating and maintenance labor hours per day	Qt.	C	Transit records.
4.9 Demonstration operating costs per day in dollars, classified by: vehicle related (associated maintenance); driver related; support related (including hardware sub-systems and associated maintenance); administrative and other costs (including public liability insurance)	Qt.	C	Demo grantee records.

EXHIB. 7 (CONT)

Measures: IV. Productivity	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
4.10 Driver utilization (vehicle hours x average base driver rate divided by total driver payroll)	Qt.	D	4.7 x (base driver rate) divided by (total daily driver payroll).
4.11 Vehicle in-service miles per * total vehicle miles	Qt.	D	(Vehicle in-service miles) divided by 4.5.
4.12 Vehicle in-service hours per * total vehicle hours	Qt.	D	(Vehicle in-service hours) divided by 4.7.
4.13 Peak vehicle utilization (vehicles in operation during peak period divided by total vehicle fleet)	Qt.	D	(Vehicles in operation during peak period) divided by 4.1.
4.14 Vehicle miles per vehicle per day	Qt.	D	4.5 divided by 4.1.
4.15 Seat miles per vehicle per day	Qt.	D	4.6 divided by 4.1.
4.16 Vehicle hours per vehicle per day	Qt.	D	4.7 divided by 4.1.
4.17 Operating costs in dollars per vehicle per day	Qt.	D	4.9 divided by 4.1.
4.18 Operating costs in dollars per vehicle mile	Qt.	D	4.9 divided by 4.5.
4.19 Operating costs in dollars per seat mile	Qt.	D	4.9 divided by 4.6.
4.20 Operating costs in dollars per vehicle hour	Qt.	D	4.9 divided by 4.7.

* These ratios can be used to convert productivity measures from a total miles or total hours basis to an in-service miles or hours basis.

EXHIB. 7 (CONT)

Measures: IV. Productivity	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
4.21 Operating costs in dollars per vehicle trip (fixed route systems)	Qt.	D	4.9 divided by 4.4.
4.22 Number of passengers per day	Qt.	C	Counts by drivers, on-board observers or on-street observers; transit revenue records.
4.23 Passenger in-vehicle trip length in miles	Qt.	C	Surveys.
4.24 Number of passenger miles per day	Qt.	D	4.22 x (average in-vehicle trip length)
4.25 Number of passenger hours per day	Qt.	D	4.22 x (average in-vehicle trip time)
4.26 Transit (fare box) revenue per day in dollars	Qt.	C	Transit revenue records.
4.27 Passengers per vehicle trip (fixed route systems)	Qt.	D	4.22 divided by 4.4.
4.28 Passengers per vehicle mile	Qt.	D	4.22 divided by 4.5.
4.29 Passengers per vehicle hour	Qt.	D	4.22 divided by 4.7.
4.30 Passenger miles per seat mile	Qt.	D	4.24 divided by 4.6.

EXHIB. 7 (CONT)

Measures: IV. Productivity	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
4.31 Passenger hours per vehicle hour	Qt.	D	4.25 divided by 4.7.
4.32 Depreciated capital costs (on an annual basis) in dollars per passenger	Qt.	D	(Depreciated capital costs) divided by (4.22 x number of operating days per year).
4.33 Depreciated capital costs (on an annual basis) in dollars per passenger mile	Qt.	D	(Depreciated capital costs) divided by (4.24 x number of operating days per year).
4.34 Operating costs in dollars per passenger	Qt.	D	4.9 divided by 4.22.
4.35 Operating costs in dollars per passenger mile	Qt.	D	4.9 divided by 4.24.
4.36 Operating costs in dollars per passenger hour	Qt.	D	4.9 divided by 4.25.
4.37 Revenue per passenger	Qt.	D	4.26 divided by 4.22.
4.38 Operating cost ratio (operating costs/revenue)	Qt.	D	4.9 divided by 4.26.
4.39 Park-and-ride lot utilization (number of vehicles divided by number of available spaces)	Qt.	D	(On-site counts of vehicles) divided by 2.12.

EXHIB. 7 (CONT)

Measures: V. Service for the Transit Dependent	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
5.1 Service area in square miles	Qt.	C	Project description; obtained from observed travel patterns or origin-destination data in surveys.
5.2 Number of vehicles by type	Qt.	C	Transit records.
5.3 Seated vehicle capacity by type	Qt.	C	Transit records.
5.4 Standing vehicle capacity by type	Qt.	C	Transit records.
5.5 Route miles by type of vehicle (fixed route systems)	Qt.	C	Transit records.
5.6 Tour area (non-fixed route systems)	Qt.	C	Transit records.
5.7 Route miles per square mile of service area by type of vehicle (fixed route systems)	Qt.	D	5.5 divided by 5.1.
5.8 Vehicles per square mile of service area by type of vehicle (non-fixed route systems)	Qt.	D	5.2 divided by 5.1.
5.9 Service frequency (fixed route systems)	Qt.	C	Real-time surveillance system; on-street observer; transit records.
5.10 Time of service operation throughout the day	Qt.	C	Transit records.
5.11 Days of service operation throughout the year	Qt.	C	Transit records.

EXHIB. 7 (CONT)

Measures: V. Service for the Transit Dependent	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
5.12 Directness of system routing (percentage of person trips requiring no transfers)	Qt.	C/D	Surveys; derived from schedules and hypothetical origin-destination patterns.
5.13 Fare structure and special payment arrangements	Qt.	C	Transit records.
5.14 System seat availability by type of vehicle	Qt.	C	On-street observers; surveys.
5.15 Service area target population (number of persons who are eligible to use SMD service)	Qt.	C	Census/local data.
5.16 Target population density	Qt.	C	5.15 divided by 5.1.
5.17 Number of persons who actually use SMD service (where registration is required)	Qt.	C	Registration records.
5.18 Number of persons who actually use SMD service	Qt.	C	Surveys in service areas; registration records, if applicable.
5.19 Percent of target population using SMD service	Qt.	D	5.18 divided by 5.15.
5.20 Percent of service area trips diverted to SMD service from auto and other transit/paratransit modes	Qt.	C	Surveys.
5.21 Person distances in miles to system access points	Qt.	C	Measurements based on site maps/surveys
5.22 User access/egress modal split (sub-modal split)	Qt.	C	Surveys.
5.23 Trip production rates (by mode, purpose, etc.)	Qt.	C	Surveys.

EXHIB. 7 (CONT)

Measures: Service for the V. Transit Dependent	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
5.24 Number of person trips in a given time period that could be made using the SMD service	Qt.	C	Surveys.
5.25 Number of person trips in a given time period actually made using SMD service	Qt.	C	Surveys.
5.26 SMD service market share	Qt.	D	5.25 divided by 5.24.
5.27 Perceived convenience of SMD service to users	Qt.	C	Surveys.
5.28 Perceived accessibility of SMD service to users	Qt.	C	Surveys.
5.29 Number of vehicle hours per day	Qt.	C	Transit records.
5.30 Demonstration operating costs per day in dollars	Qt.	C	Demo grantee records.
5.31 Operating costs in dollars per vehicle hour	Qt.	D	5.30 divided by 5.29.
5.32 Number of passengers per day	Qt.	C	Counts by drivers, on-board observers or on-street observers; transit revenue records.
5.33 Actual passenger in-vehicle trip time in minutes	Qt.	C	Observers in vehicles or at points along route.
5.34 Perceived passenger in-vehicle trip time in minutes	Ql.	C	Surveys.
5.35 Passenger in-vehicle trip length in miles	Qt.	C	Surveys.

EXHIB. 7 (CONT)

Measures: V. Service for the Transit Dependent	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
5.36 Transit (fare box) revenue per day in dollars	Qt.	C	Transit revenue records.
5.37 Passengers per vehicle hour	Qt.	D	5.32 divided by 5.29.
5.38 Operating costs in dollars per passenger	Qt.	D	5.30 divided by 5.32.
5.39 Revenue per passenger	Qt.	D	5.36 divided by 5.32.
5.40 Operating cost ratio (operating costs/revenue)	Qt.	D	5.30 divided by 5.36.
5.41 Variability of transit trip time	Qt.	D	Standard deviation of actual transit trip time divided by average actual transit trip time.
5.42 Difference between promised and actual vehicle arrival time at pick-up points (non-fixed route systems)	Qt.	D	(Actual arrival time from driver log) minus (scheduled arrival time from dispatcher log).
5.43 Difference between scheduled and actual transit headway (fixed route systems)	Qt.	D	(Actual time between vehicles noted by on-street observer or surveillance system) minus (scheduled interval from schedules).

EXHIB. 7 (CONT)

Measures: V. Service for the Transit Dependent	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
5.44 Perceived reliability of SMD service to users (i.e., to get to destination on time)	Q1.	C	Surveys.
5.45 Perceived comfort of SMD service to users	Q1.	C	Surveys.
5.46 Attitudes towards SMD service of users and non-users	Q1.	C	Surveys.

EXHIB. 7 (CONT)

Measures: VI. Other Basic Measures	Type of Measure	Collected or Derived	Possible Collection/Derivation Techniques
6.1 Auto volumes	Qt.	C	Roadside counts by observers; mechanical tube counters; vehicle surveillance and control system; aerial photographs; closed circuit TV; electronic detectors.
6.2 Auto occupancy	Qt.	C	Roadside counts by observers.
6.3 Auto person trips	Qt.	D	6.1 multiplied by 6.2.
6.4 Description of congestion and congestion points in service area	Qt./Ql.	C	Floating car on arterials and freeways with observers to note congestion points and record stopped time delay using stop watches; aerial photographs.
6.5 Duration of peak periods	Qt.	D	Analysis of auto and transit volumes.
6.6 Fuel consumption	Qt.	D	Appropriate analytical models.
6.7 Air emissions	Qt.	D	Appropriate analytical models.
6.8 Land use patterns--residential/ industrial development	Qt./Ql.	C	Zoning ordinances; observations of area; aerial photographs.
6.9 Economic indicators--e.g., retail sales, unemployment rates	Qt.	C	Census, local data.
6.10 Community attitudinal profile	Ql.	C	Surveys.

plans is discussed separately in Section C, Part 2 of this chapter.

The entire set of measures in Exhibit 7 is not to be construed as a minimum requirement for every SMD project, since an evaluation need only encompass measures corresponding to the SMD Program objectives and other project objectives/issues addressed by the particular demonstration. Nor is the group of measures corresponding to each of the five SMD Program objectives to be considered a minimum set for that objective. Rather, Exhibit 7 should be used by the contractor as a checklist from which the most germane measures can be collected and to which other relevant measures can be added as appropriate.

It will be noted that for each of the SMD Program objectives, it is possible to measure attainment of the objective from two vantage points: the actual and the perceived attributes of the transit system (as represented by quantitative and qualitative measures, respectively). In the case of transit travel time, it might be appropriate to measure actual changes in travel time as well as to assess user perceptions of changes in travel time and then to compare the two. Similarly, it might be interesting to obtain non-user impressions of transit system coverage and correlate these impressions with actual coverage measures. In the case of productivity and equipment reliability measures, comparisons with transit operator perceptions might also be appropriate.

Until more is learned about the interrelationship between actual measurements and attitudinal data, it is not possible to set forth hard and fast rules for when to supplement quantitative measures with qualitative measures. Clearly, it would be prohibitively expensive to employ this two-pronged procedure for each area of interest; on the other hand, mere reliance on quantitative measures may result in overlooking what is in fact the major behavioral determinant -- people's perceptions of the system. For the time being, the contractor must exercise sound judgment in deciding which situations are unique and instructive enough to warrant a two-pronged collection effort. In no case should an attitudinal measure ever be used in place of a quantitative measure, where both are available.

The philosophy or rationale underlying each group of measures in Exhibit 7 is discussed below. Further discussion of collection/derivation techniques appears in Part 2 of this section.

TRAVEL TIME

The primary measure to be collected under this objective category is travel time as measured in minutes. It is fairly clear that transit travel time can be addressed in terms of the passenger (actual or perceived) and the vehicle (actual or scheduled). Since the private auto may well be a factor in both a transit user's total trip time and as an alternative mode to transit, auto travel time is also important.

COVERAGE

Many factors and important measures may influence the coverage and assessment of coverage for a specific transit system. To illustrate, the impact of park-and-ride lots on service area boundaries may cause the potential extension and/or redefinition of the service area. An examination of those measures associated with increasing transit coverage indicates that there are three major aspects, namely, spatial coverage, temporal coverage, and access potential to the system. Some of the derived measures are dependent upon site-specific measures discussed earlier in these guidelines.

It should be noted that market share has been defined as the number of person trips made using the SMD service divided by the number of person trips that could be made using the service. For projects where the names of SMD service users are kept on file, it may be appropriate to compute an additional measure, the percent of service area target population using the SMD service.

RELIABILITY

The next SMD Program objective is the improvement of transit reliability. In this area it is important to differentiate among:

(1) Adherence of transit vehicles to schedules (dependability);

(2) Reliability of both vehicles and support equipment; and,

(3) Maintainability of both vehicles and support equipment.

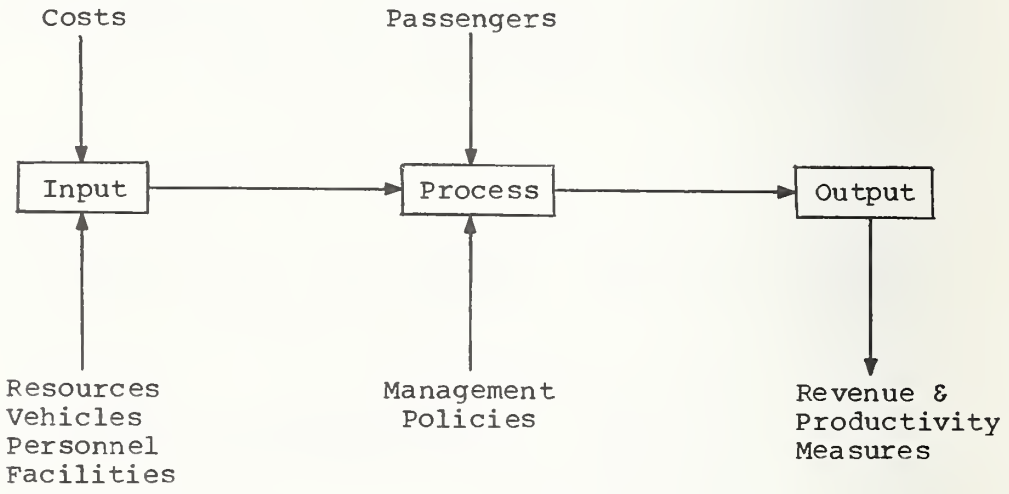
The assessment of adherence to schedule is fairly straightforward. The determination of measures for reliability and maintainability associated with transit vehicles, however, requires a clear definition of what constitutes a failure and a distinction between preventive maintenance (scheduled) and repair (unscheduled maintenance).

PRODUCTIVITY

Transit productivity describes how a system and its resources are allocated and managed for purposes of providing an effective transit system. In essence, productivity improvements come about through one or both of the following: increased level of service provided per unit of cost, and increased number of passengers carried per unit of service provided.

Transit productivity is depicted in Exhibit 8 as an input-process-output system.

EXHIBIT 8. TRANSIT PRODUCTIVITY AS AN INPUT-PROCESS-OUTPUT SYSTEM



The system input consists of available resources such as vehicles, personnel, facilities, and associated cost. The manner in which these resources are used is the system process. This process is influenced by the transit management policies and the manner in which passengers utilize the transit system. The next step is to assess the influence of the associated resources and management policies by collecting output in the form of various productivity measures.

Productivity measures, as given in Exhibit 7, are essentially organized in terms of the above-mentioned elements: input (what is being put on the street and at what cost), process (how are the resources being managed and at what cost) and output (how do resources relate to passenger utilization and at what cost).

TRANSIT DEPENDENT

The SMD Program objective of improving service for the transit dependent essentially comprises a combination of the first four SMD objectives in the context of one or more special target groups (handicapped, elderly, jobless, etc.). Accordingly, many of the measures appearing in the fifth section of Exhibit 7 are similar or identical to measures presented in preceding sections.

Since the most significant transportation-related problem of these target groups is typically limited mobility, measures relating to coverage will be relevant for most evaluations. In particular, it will be desirable to (1) measure increases in the target group trip production rates by trip purpose, and (2) record perceptions by the target group and others regarding social gains from the increased transit coverage and attendant mobility changes. Although projects addressing the fifth SMD Program objective may not explicitly address travel time, reliability, and productivity issues, an examination of the impact of a new or expanded service on these areas may be needed in order to obtain a full assessment of the demonstration.

The Glossary contains definitions relevant to the transit dependent. Revisions to these definitions, and possibly to the list of measures applicable to specific target groups, may occur as information becomes available from an ongoing research effort within UMTA on transportation problems of the transportation handicapped.

OTHER BASIC MEASURES

The last section of Exhibit 7 contains measures which, while not directly applicable to the five SMD Program objectives, might be relevant in the context of local or national concerns. Energy consumption and air pollution are two issues which in some cases constitute the direct impetus for transportation improvements undertaken at a demonstration site. Land use patterns and the community attitudinal profile are examples of measures relating to the longer term, more indirect impact of SMD innovations.

It is anticipated that the group of measures in this section will be expanded and refined over the course of the SMD Program to reflect the growing number of issues which are relevant to individual demonstrations and the evolving consensus of opinion as to how these issues should be addressed.

2. Data Collection/Derivation Techniques

Once the relevant measures for project evaluation have been determined, it is necessary to identify appropriate collection or derivation techniques. Collected measures can be obtained through the following four basic methods:

(1) By measurements, using various instruments, such as stopwatches, odometers, and speedometers. The accuracy of the recorded data is a function of the accuracy of the measuring instrument itself. Typical measurements include travel times and vehicle velocities.

(2) By counts or observations involving tallies either from discrete digitized recording equipment or from counts made by individuals. Typical counts would be numbers of passengers in vehicles.

(3) By surveys or interviews which provide information relative to the individual being questioned, said information to include such items as origin, destination, income level, previous travel modes, observations of how the service is functioning, and attitudes towards transit amenities.

(4) By searching records such as those available through the transit system, local grant recipient, and other local planning agencies and Census records.

Derived measures can be calculated either through the use of simple arithmetic processes or special analytic models. This category of measures builds upon basic data collected through some of the above means. An illustration of the former type of derived measure might be dividing passengers per day by vehicle miles per day to obtain passengers per vehicle mile. Examples of the latter type of derived measure might be the use of a time-delay curve to estimate vehicle speeds or the calculation of reductions in fuel consumption and air pollution based on changes in traffic volumes. At present, there are no preferred models for calculating the derived measures included in Exhibit 7.

In view of the large number and variety of measures in Exhibit 7 and the even larger number which are likely to arise during the course of the SMD Program, it would be very difficult to specify in these guidelines a preferred method of data collection for each measure. Moreover, given the rather limited experience to date in conducting transit demonstrations, it would be inappropriate to attempt to choose a set of "best" methods from among the techniques already tried; rather, it is desirable to encourage the continual development and implementation of novel techniques with potential for increasing the efficiency or accuracy of evaluations. Finally, there is really no requirement for uniformity among data collection techniques, but rather there is a need for consistency and comparability of the data obtained by these collection techniques. The techniques can differ from project to project, so long as they are comparable in terms of accuracy and yield data in a form suitable for analysis both within the project and among projects.

For the above three reasons, it is not the intent here to prescribe a standardized approach to data collection. However, it is appropriate to discuss the potential applicability of some of the specific techniques listed in Exhibit 7, drawing where possible from previous experience related to UMTA demonstrations.

Exhibit 9 illustrates the range of techniques employed for selected measures in four recent UMTA projects. Specific comments on these techniques and general recommendations applicable to collecting the measures follow:

(1) Travel time, speed, and vehicle volume data collection techniques can range from manual to automatic. In general, automatic techniques are more costly than manual, and thus are cost-effective only where the magnitude of data

EXHIBIT 9. DATA COLLECTION TECHNIQUES FOR SELECTED MEASURES USED IN RECENT UMTA DEMONSTRATION PROJECTS

Travel times for transit vehicles:

- On-board checkers with stop-watches (Minneapolis)
- On-street checkers with stop-watches (Shirley Highway)
- Time referenced cassette recorders connected to bus odometer (Miami)

Speeds for transit vehicles and autos:

- On-street checkers (Shirley Highway)
- Test vehicle with use of an odometer, clock, and digital tape recorder (Miami)
- Real-time surveillance system (Shirley Highway, Minneapolis)

Counting auto occupants:

- On-street counts recorded on cassettes (Miami)
- Special manual counting devices (Shirley Highway)

Counting transit vehicle passengers:

- On-board checkers manually recording data (Minneapolis)
- On-street counts recorded on paper, counters, or cassettes (Shirley Highway, Miami)
- Bus drivers recording passenger load (Seattle)

Travel times for autos:

- On-street checkers at selected locations recording license plates and times; calculation of elapsed time by matching plates (Shirley Highway)
- Time lapse aerial photographs (Miami)
- Floating car with observers to record travel time and stopped time delay using stop-watches (Miami, Seattle, Minneapolis)

Counting of transit vehicles and autos:

- Permanent or temporary mechanical tube counters over lanes or zones of interest (Minneapolis, Seattle, Miami)
- Visual counts recorded by persons or on special counters (Miami, Shirley Highway)
- Time lapse aerial photographs (Miami)
- Real-time surveillance system (Minneapolis)
- Electronic detectors (Miami)

Demographic/behavioral/attitudinal data on users/non-users/operators:

- Post cards distributed to auto drivers at exit ramps, to boarding and on-board passengers, and at park-n-ride facilities (Seattle).
- Forms, usually no longer than one page, distributed and returned by mail (Shirley Highway) or collected on buses (Seattle)
- Sampling of autos by noting license plates and subsequent identification through Department of Motor Vehicles files (Shirley Highway)
- Interview conducted either at home, work, or within the transit system itself (on board, at stations, etc.) or with transit or local officials (Minneapolis, Miami)

requirements or some other special circumstances warrant their use.

Some of the more sophisticated automatic procedures are subject to reliability problems. Failure of these devices can cause loss of vital data, which will in turn delay the evaluation, and considerably increased costs. In addition, the measurement accuracy of automatic or semi-automatic devices may be questionable, particularly if they have not been used extensively before. In cases where definitive information on device accuracy is not available, it is essential to confirm the accuracy of automatically collected data by periodic use of manual devices.

Simple manual devices can be deployed so as to maximize utilization of roadside personnel. For example, in the Shirley Highway project, the use of special counters by each observer permitted keeping track of the auto occupancy of each vehicle counted, with the result that two measures were obtained at once. The Miami project is also using special manual devices to obtain vehicle counts and occupancy data simultaneously.

(2) Experience with past demonstrations has shown that there is a lack of consistency between passenger counts recorded by transit personnel and counts by on-board or roadside observers. For instance, in the Seattle project it was found that bus drivers tend to overestimate the passenger load while on-board and on-street counters tend, on the average, to be consistent with each other. If transit personnel are to record such data, it is essential that verifications be made during the project to detect any potential bias or unusual variability in this data.

(3) In utilizing transit system records and service area records, such as census data, it is critical to ascertain accuracy of this data. Usually, discussions with personnel who initially record this data will provide an assessment of accuracy. Further, where special data is collected for the project by a local organization, monitoring procedures will be established to assure that no modifications in procedures or notations have occurred which might have an impact on the evaluation process.

Great care should be taken in utilizing fare box revenue as a basis for arriving at passenger counts. The adequacy of this approach has been shown to depend heavily on fare structure, considering prices, zones, time of day, and revenue versus non-revenue loads.

(4) Demographic, behavioral, and attitudinal data on users and non-users of the demonstration service, as well as attitudinal information from transit operators, can be collected through a wide variety of survey and interview techniques, with varying degrees of respondent cooperation, accuracy, and cost. In view of the large amount of documented survey experience relating to both transportation and general market research contexts, and in view of the large anticipated role of surveys in SMD evaluations, an entire appendix has been devoted to a discussion of survey design and execution.

In evaluating the array of existing and potentially innovative collection techniques relative to a particular measure, some of which are included in Exhibit 7 as examples, the contractor should consider factors such as the cost and accuracy of each method, the availability of local resources to implement each method, the ease of implementation, and the ultimate data analysis requirements.

With respect to cost, the contractor should apply sound judgment in determining whether the anticipated cost of using a particular technique is justifiable in terms of the contribution to the overall project evaluation of the specific measure being collected. Clearly, the total project expenditure for data collection should be allocated among individual measures, taking into account each measure's contribution to the project evaluation. The contractor should make special note of any data item which is relevant to the evaluation but whose collection cost appears to be disproportionately high in relation to other items.

The contractor should determine, again on a judgmental basis, whether the accuracy of a particular technique is consistent with the accuracy requirement for the measure, which in turn is dependent on the relative importance of the measure. A very accurate technique is probably not warranted for a relatively insignificant measure, especially if that technique would be expensive to implement. In addition, a high degree of accuracy for some measures may be inconsistent with a lesser degree of accuracy for others.

The contractor should also evaluate alternative techniques in light of the available local resources -- manpower as well as equipment. An attempt should be made to utilize existing equipment wherever feasible, rather than opting in favor of techniques which require the purchase of new equipment (which might not be needed by the locality after the demonstration evaluation).

The contractor's Evaluation Plan should contain justification for selecting the particular technique applicable to each measure in terms of these considerations. In the case of a novel technique, it is required that the contractor demonstrate acceptable accuracy before it can be used as the sole source for data collection. It is further required that the evaluation contractor document his experience with those data collection methods employed in an evaluation, as explained below in Chapter IV. As this further experience develops, TSC will make this information available via updates to the Guidelines document.

C. PLANNING CONSIDERATIONS RELATIVE TO DATA COLLECTION AND ANALYSIS

The preceding section contained guidelines relative to specifying appropriate measures and collection/derivation techniques for addressing SMD Program objectives and other project objectives and issues. This section completes the discussion of evaluation planning activities with general guidelines for data collection and analysis procedures. The material in this section, while intended to be applied to individual measures selected for inclusion in the evaluation, is presented in a general context. The following topics are included: basic data collection/analysis design, measure stratification, sampling requirements, and the timing of data collection.

1. Basic Data Collection/Analysis Design

A significant aspect of the evaluation process for SMD demonstrations is determining the basic data collection/ analysis design to be employed relative to specific project objectives. There are a great variety of potential approaches, ranging from an "after-only" design (a one-shot case study approach involving a single set of measurements taken after the demonstration is operational) to a "before-after with control group" design (involving a comparison of

multiple measurements). A comprehensive discussion of the specific utility and the relative pros and cons of the various design approaches can be found in Chapter 4 of Charles River Associates, Measurement of the Effect of Transportation Changes, September, 1972, and in Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, Rand McNally and Company, Chicago, 1968. The information which follows is intended to discuss the relative advantages of various approaches in the context of the SMD program and to highlight the major considerations involved in selecting the appropriate design for each SMD evaluation, or for individual measures included in the evaluations.

In general, a single set of measurements (for example, taken while the demonstration is in operation) will be insufficient for assessing the impact of the demonstration, since it will not provide any yardstick with which to interpret the measurements. It is recommended, therefore, that every data collection/analysis program be structured around some form of comparison. If such an approach is for some reason infeasible, the contractor must indicate the reason(s) in the Evaluation Plan.

Given that the basic data collection/analysis design will generally be in the form of a comparison of multiple measurements, the next question to be considered is what types of comparison are appropriate. The two main forms of comparison are before vs. after and test vs. control. In a before-after comparison, a given measure is collected on a given system element before the experimental or exemplary demonstration technique is instituted and then again while the technique is operational.* In a test-control comparison, a given measure is collected on a system element which has been affected by the introduction of a demonstration technique (test unit) and also on an equivalent system element which has not been similarly treated (control unit). Each type of comparison is somewhat

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*As is discussed below, a before-after comparison does not necessarily imply a single measurement before the demonstration is implemented and another measurement while it is operational. Rather, this type of comparison can take the form of a series of measurements prior to, during, and after the operational phase of the demonstration. If the project is implemented in stages, there will be a series of measurements corresponding to each stage.

limited: the before-after comparison fails to show what portion of the change in the measure is due to exogenous factors unrelated to the demonstration; the test-control comparison shows the difference between "after" measures and hence accounts for exogenous factors, but fails to indicate the degree of change from the before state to the after state. Accordingly, it is desirable, where feasible, to conduct a before-after comparison in conjuction with a test-control comparison. In other words, the data collection/analysis design should if possible involve observation of both a control and test unit before and after the institution of the treatment.

To make the foregoing discussion more concrete, consider a large area with many bus routes and suppose that a certain fraction of them are treated in some manner -- i.e., a technique is implemented which can be expected to reduce bus travel time. If pre-treatment and post-treatment measures of travel time are made only on the treated routes and a reduction in time is indicated, there is no way of knowing the extent to which the improvement is attributable to exogenous factors (for instance, a decrease in auto traffic on the streets where the buses operate). In order to account for, in a quantitative fashion, these known or unknown factors which have arisen during the interval between the before and after measurements, it is necessary to make before and after measurements of bus travel time on routes which are comparable to the test routes and therefore susceptible to the same set of exogenous factors. The difference between the travel time reduction on the test vs. control routes can then be taken as the true change due to the treatment. To make these statements it is necessary to be fairly confident that conditions affecting both control and experimental units are "reasonably" similar -- a requirement which is sometimes difficult if not impossible to assure.

To reiterate, the proper use of the combined before-after/test-control approach guarantees to the greatest extent that any observed improvement is indeed due to a demonstration technique. Thus the contractor should employ both types of comparisons wherever appropriate and feasible.

The determination of appropriateness of the combined approach involves a consideration of the nature, scope, and time span of the demonstration project. Regarding the nature of the project, the key issue is whether it is exemplary or experimental (see Chapter II, Section A for a description of these two SMD categories). In general, the exemplary demonstrations are less investigative than the experimental demonstrations--that is, there is a much

greater a priori knowledge of the probable effects of the techniques or services being applied than in the case of experimental demonstrations. Thus, the levels of accuracy and capability for hypothesis testing which are inherent in a combined before-after/test-control approach may not be required; before-after measurements on just the test units may be sufficient.

Regarding the scope of the project, exemplary demonstrations will generally be implemented on a significantly larger scale than the experimental demonstrations, since they are aimed at illustrating the benefits of certain techniques and/or services in a full-fledged operational environment, whereas the experimental projects are aimed at determining the feasibility of a particular service or technique in a simulated or miniaturized operational environment. The larger the geographic area encompassed by or affected by the project, the greater the possibility that no control units can be identified (i.e., the entire population is composed of test units).

Regarding the time span of the project, no generalizations can be made with respect to exemplary vs. experimental demonstrations, since projects will vary in length depending on a variety of other factors. As a general rule-of-thumb, the desirability of the combined before-after/test-control approach increases with the time span of the project, since this approach reveals endogenous as well as exogenous changes occurring over the project's duration.

The determination of feasibility of the combined approach involves questions of data availability and project timing. If there is a known deficiency in either type of comparison, then only the valid comparison should be employed; it is generally better to do without a before observation or a control observation than to settle for unsuitable before or control data. In the event that only one type of comparison is feasible, there are alternative techniques and precautionary measures available to the contractor to compensate for the absence of the other type of comparison.

If no control group exists (e.g., if the demonstration affects the entire population of observation units, making each one a test unit) or if no suitable group can be found (each test unit is unique), then the contractor should be especially observant throughout the evaluation period of possible exogenous factors which might influence the interpretation of project results. Any statistics regarding

the before vs. after change due to the demonstration technique should be examined very carefully in the context of these observed exogenous factors, and any conclusions based on such statistics should be qualified accordingly.

If, due to project timing, there is no opportunity to perform before measurements, or if it is known beforehand that the units to be observed will undergo considerable change between the before and after periods, the contractor should attempt to obtain surrogate data for the before period. Possible sources of surrogate data would include (1) surveys conducted after the demonstration is operational which question people about conditions or their behavior prior to the implementation of the demonstration technique and (2) demographic and travel data collected by the local highway department, planning agency, or transit operator some time prior to the demonstration. The surrogate data can be used to provide some indication of the magnitude of the before-after change experienced by the test and control groups.

In using the before-after and/or test-control approach, one of the key steps is identifying comparable units. To as great an extent as possible, the units observed for the before case must be equivalent to the units observed for the control units. Returning to the previous example of bus routes, before-after comparability is not a difficult problem, since the same routes can be observed for both time periods. The only note of caution is that the routes should be unchanged (with respect to length, number and location of stops, etc.) from one measurement period to the next.

Test-control comparability, on the other hand, raises some interesting problems. Theoretically the test and control units should be as nearly alike as possible to rule out any chance of the observed change being a result of something other than the experimental treatment. Test and control units should be chosen which are similar in terms of variables assumed to be related to the particular measure. Again using the example of bus routes and the measure travel time, matching of test and control routes could be done on the basis of such descriptors as route length, total trips along the route, peak headway, and average speed.

TSC's Evaluation Framework will generally suggest the basic data collection/analysis design to be employed for each project as a whole or for particular measures -- i.e., before-after comparison, test-control comparison, both types of comparison, or a single set of measurements. The contractor should determine the feasibility of such suggestions in terms of the data availability and time

framework of the particular project and site. The contractor's Evaluation Plan should then elaborate on the approach finally selected for each measure, indicating information such as the specific units chosen for the control and test groups.

2. Measure Stratification

Measure stratification refers to the categorization of individual measures for collection/derivation and/or analysis purposes. Examples of measure stratification are:

(1) Peak versus off-peak time periods

(2) Day of the week

(3) Revenue (in-service) versus non-revenue service

(4) Waiting, access, transfer and in-vehicle travel times

(5) Fixed route versus demand responsive.

Measure stratification improves the quality of the evaluation by allowing an assessment of how changes in measures relate to the stratification categories, hence increasing the transferability of results.

Whereas collection of an unstratified measure provides only a single, average reference point, the use of a stratified measure provides a series of reference points, each of which may be significant to the analysis and interpretation of results. Knowledge of intercategory differences in results enhances transferability: for instance, if a particular demonstration service proves to be especially beneficial in congested areas but of limited value in sparsely traveled areas, then other sites considering implementation of the service will know to focus their efforts in congested areas.

Stratification can take the following forms:

(1) Categorization of a measure into additive components -- e.g., measuring person trip time in terms of trip components such as access time, line-haul time.

(2) Categorization of a measure, and possibly its components, according to target market, operational, geographic, or time categories -- e.g., measuring trip time for peak and off-peak periods.

(3) Grouping of raw values of a measure into class intervals, with class intervals determined either before or after data collection -- e.g., determining the distribution of early, late, and on-time arrivals.

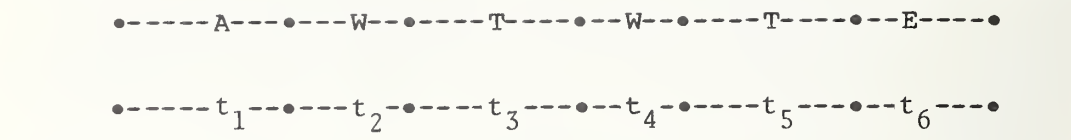
It is not possible at this time to present a standardized approach to be used for each measure. Clearly, the appropriate type and level of stratification depend on the particular measure and on the characteristics of the site and project. It is anticipated that a standardized approach to measure stratification will evolve over time, as experience is gained regarding the incremental benefits associated with each degree of stratification. However, in order to provide the contractor with some guidance in this area, examples of possible types and levels of stratification are presented below.

a. Categorization of a Measure Into Additive Components

This form of stratification involves collecting and reporting data separately for specific components, or sub-breakdowns, of a measure. The purpose of categorizing in this manner is to single out the effect of an SMD innovation on these specific components. Examples of this form of stratification are available for measures relating to travel time, reliability, and productivity.

Person transit trip time for fixed route systems can be broken into segments as depicted in the following diagram:

Origin Destination



where:

Segment A = Access time
Segment W = Waiting time for first vehicle or for subsequent transfer
Segment T = In-vehicle transit time
Segment E = Egress time
t_i = Time for ith trip segment

If further amplification is desired, access time and egress time can be subdivided into walking, riding, and other portions; or in-vehicle transit time can be subdivided into collection, line-haul, and distribution phases.

In the case of demand-responsive systems, some of the trip time components might take on a different definition: for example, access time would be zero, and waiting time would refer to the difference between the caller's requested time of pickup and the arrival time of the vehicle at the origin. In cases where the caller is told that pickup can only be made later than the requested time,* wait time can be further divided into the time between the requested pickup time and the promised pickup time, and the time between the promised pickup time and the arrival time of the vehicle at the origin. This latter travel time component, is, in itself, a basic reliability measure. In-vehicle transit time, if desired, can be divided into the direct routing travel time (the time between the person's origin and destination if no other pickups or dropoffs are made) and the detour travel time (the time spent detouring to make other pickups and dropoffs).

As can be seen in Exhibit 7, transit vehicle time is always to be broken into in-service time and non-service

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*Due to the potential ambiguity associated with requests for immediate service, the contractor should note how the particular transit operator maintains data on requested and promised pickup times.

time. However, if desired, these two prime categories can be further divided as indicated below.

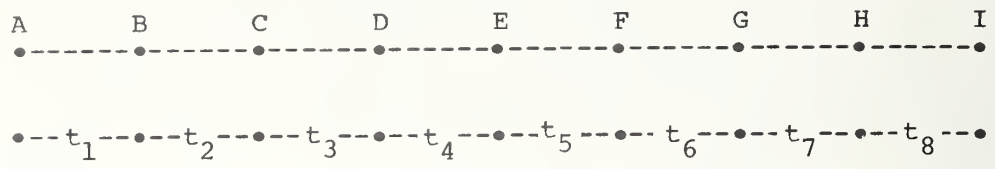
For fixed route systems:

- In-service
  - In motion
  - Loading
  - Non-productive -- waiting for lights, metering, or other obstacles to motion
- Non-service
  - Garage to first service point
  - Last service point to garage
  - Dead turn-around time
  - Deadhead time
  - Other

For demand responsive systems:

- In-service
  - In motion with one or more passengers onboard
  - In motion with no passengers onboard and in the act of picking up one or more passengers
  - Loading
- Non-service
  - Garage to first pickup point
  - Last dropoff point to garage
  - Between first pickup point and last dropoff point with no passengers onboard and not in the act of picking up one or more passengers

These time segments are depicted in the following diagram:



where:

Point A = Garage
B = First pickup point
C = Dropoff point -- no passengers on vehicle but driver is instructed to proceed immediately to pick up a passenger
D = Pickup point
E = Dropoff point -- no passengers on vehicle and there are no requests for immediate pickup; driver is instructed to proceed to central waiting point
F = Point en route to central waiting point -- driver is instructed to proceed immediately to pick up a passenger
G = Pickup point
H = Last dropoff point of day
I = Garage

Note that in segments BC and GH pickups and dropoffs are being made and at least one passenger is always onboard.

$$\text{In-service time} = t_2 + t_3 + t_4 + t_6 + t_7$$

$$\text{Non-service time} = t_1 + t_5 + t_8$$

Schedule reliability measures, like basic measures relating to travel time, can be broken into individual trip segments. Equipment reliability measures (for instance, vehicle delay time in minutes due to breakdown) can be stratified by type of breakdown, possible categories being mechanical, electrical, tires, etc. The decision as to whether or not to use such a breakdown would depend on the degree of emphasis on equipment reliability. This breakdown would probably be appropriate only in projects involving new vehicle types, where a detailed record of failures is necessary for design modifications.

For operating costs of SMD demonstrations, it has been decided that the following categorization scheme be used:

Vehicle-related
Driver-related
Support-related
Administrative and other costs

This four-category breakdown of costs appears to be an appropriate type and level of stratification for measuring the effect of SMD innovations on operating costs. However, it should be pointed out that this breakdown will not be available from transit company records but will have to be derived by aggregating individual cost items.

The aggregation of cost items should be consistent with project FARE expense categories.* Exhibit 10 is a matrix showing the distribution of expense object classes into functional areas under the FARE system. For the time being, until further examination of the FARE classification scheme and definitions is completed, it is recommended that the four categories of operating cost be derived by aggregating the 17 functional categories as follows:

Vehicle-related:
- 050 Servicing revenue vehicles
- 060 Inspection and maintenance - revenue vehicles
- 070 Vandalism repairs - revenue vehicles

Driver-related:
- 030 Revenue vehicle operation

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*UMTA, in cooperation with the American Transit Association and the Institute for Rapid Transit (now merged into the American Public Transportation Association) sponsored Project FARE (Uniform Financial Accounting and Reporting Elements) to develop and test a consistent reporting system for transit company financial operating data. Although this system has not yet been implemented on an industry-wide basis, it is desirable to have transit data that is collected under the SMD Program evaluations be consistent with the FARE system. Also, more recently a similar uniform reporting system has been developed for the taxi industry under the sponsorship of the SMD Program.

EXHIBIT 10. FARE REPORTING SYSTEM

WORKSHEET FOR FUNCTIONAL DISTRIBUTION OF EXPENSE OBJECT CLASSES - LEVEL B, AGGREGATED

Source: Arthur Andersen & Co., Project FARE Task IV Report, Vol. II: Reporting System Instructions, Report No. UMTA-IT-06-0034-73-6, November 1973.

EXPENSE OBJECT CLASSES	FUNCTIONS FOR DISTRIBUTING EXPENSE OBJECT CLASSES																	
	010 - ADMIN. OF TRANSPORTATION OPERATIONS	020 - SCHEDULING OF TRANS. OPERATIONS	030 - REVENUE VEHICLE OPERATION	040 - MAINTENANCE ADMINISTRATION	050 - SERVICING REVENUE VEHICLES	060 - INSPECTION & MAINT. - REVENUE VEHICLES	070 - VANDALISM REPAIRS - REVENUE VEHICLES	080 - SERVICING & FUEL FOR SERVICE VEHICLES	090 - INSPECTION & MAINT. - SERVICE VEHICLES	100 - MAINT. - VEH. MOVEMENT CONTROL SYSTEM	110 - MAINT. - FARE COLLECTION & CNTRG. EQUIP.	120 - MAINT. - OTHER R, O & F	130 - VANDALISM REPAIRS - R, O & F	140 - OPER. & MAINT. OF REC. POWER FACILITIES	150 - TICKETING & FARE COLLECTION	160 - GENERAL ADMINISTRATION	180 - GENERAL FUNCTION
501. LABOR:																		
01. Operators' Salaries & Wages	X		X												X	X		
02. Other Salaries & Wages	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
502. FRINGE BENEFITS:																		
15. Fringe Benefits Distribution	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
503. SERVICES:																		
01. Management Servis Fees	X	X		X											X	X		
02. Advertising Fees																X		
03. Professional and Technical Services	X	X		X											X	X	X	
04. Temporary Help	X	X		X	X			X								X	X	
05. Contract Maintenance Services					X	X	X	X	X	X	X	X	X	X			X	
06. Custodial Services												X						
07. Security Services																	X	
08. Propulsion Power															X			
09. Utilities Other Than Propulsion Power																		X
10. Dues and Subscriptions																		X
11. Travel and Meetings																		X
12. Bridge, Tunnel & Highway Tolls																		X
13. Other Services																		X
504. MATERIALS AND SUPPLIES CONSUMED:																		
01. Fuel and Lubricants			X					X										
02. Tires and Tubes			X					X										
03. Other Materials and Supplies	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X
505. CASUALTY AND LIABILITY COSTS:																		
01. Premiums for Physical Damage Insurance						X						X						
02. Recoveries of Physical Damage Losses						X						X						
03. Premiums for P L & P D Insurance																	X	
04. Payouts for Uninsured P L & P D Settlements																	X	
05. Provision for Uninsured P L & P D Settlements																	X	
06. Payouts for Insured P L & P D Settlements																	X	
07. Recoveries of P L & P D Settlements																	X	
08. Premiums for Other Corporate Insurances																	X	
09. Other Corporate Losses																	X	
10. Recoveries of Other Corporate Losses																	X	
506. LEASES AND RENTALS:																		
01. Transit Way and Transit Way Structures and Equipment																		X
02. Passenger Stations																		X
03. Passenger Parking Facilities																		X
04. Passenger Revenue Vehicles			X															
05. Service Vehicles																		X
06. Operating Yards or Stations																		X
07. Engine Houses, Car Shops and Garages																		X
08. Power Generation & Distribution Facilities															X			
09. Revenue Vehicle Movement Control Facilities	X																	
10. Data Processing Facilities																	X	
11. Revenue Collection and Processing Facilities																X		
12. Other General Administrative Facilities																		X
508. PROPERTY RETIREMENT WRITE-OFFS:																		
01. Property Retirement Write-Offs						X	X					X	X					X
510. OTHER TAXES:																		
01. Federal Income Tax																		X
02. State Income Tax																		X
03. Property Tax																		X
04. Vehicle Licensing and Registration Fees			X															X
05. Fuel and Lubricant Taxes			X					X										
06. Other Taxes																		X
511. EXPENSE TRANSFERS:																		
01. Function Reclassifications			X											(X)				X
02. Expense Reclassifications	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
03. Capitalization of Nonoperating Costs	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
512. SUBSIDY PAYMENTS:																		
01. Purchased Transportation Service																		X

Support-related:

080 Servicing and fuel for service vehicles
190 Inspection and maintenance - service vehicles
100 Maintenance - vehicle movement control system
110 Maintenance - fare collection and counting equipment
120 Maintenance - other buildings, grounds, and equipment
140 Operation and maintenance of electric power facilities
150 Ticketing and fare collection
180 General function

Administrative and other costs:

010 Administration of transportation operations
020 Scheduling of transportation operations
040 Maintenance administration
160 General administration

If more detail is required, the individual rows, columns, or cells of the matrix can be used.

Because of differences in current accounting practices within transit operations, it is essential that any techniques for disaggregation and allocation of costs be described in the Evaluation Plan. In addition, because of different funding and accounting mechanisms, it is important to review in depth individual transit authority practices.* Further, demand responsive systems will require somewhat different approaches, again to be described in the Evaluation Plan.

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*It is recognized that the reporting of operating costs should be carried out using a consistent time framework for reporting periods. Most transit operations use a monthly reporting period. This causes some distortion in the monthly cost (revenue) averages due to the variation of days of revenue service between months. Drivers' wages, fuel and oil costs, maintenance costs, and revenues are all directly proportional to the actual hours of service. This distortion can be minimized by moving to a four week reporting period (as has been done in the Rochester Service and Methods Demonstration Project), although some problems exist even here. In addition, standardized depreciation tables should be developed for different types of capital facilities and equipment.

b. Categorization of a Measure According to Target Market, Operational, Geographic, or Time Categories

The primary purpose of this form of stratification is to evaluate the effect of SMD innovations in different contexts. As in the case of categorization into additive components, this form of stratification involves collecting and reporting measures separately for each category. Examples follow:

Target Market:
- Trip purpose -- work/nonwork
- User group -- commuters/noncommuters
- Mode -- auto/transit/other

Operational:
- Type of transit service -- express/local
- Direction of traffic flow -- inbound/outbound
- Type of thoroughfare -- freeway/arterial

Geographic:
- Within/outside central business district
- Zones with different demographic characteristics

Time:
- Peak/off-peak
- Weekday/week-end

Finer stratification in the above examples is also possible. For instance, within the target market category, the trip purpose "nonwork" can be divided into medical, social, recreational, etc.; non-commuter can be stratified into elderly, handicapped, unemployed, etc.; and mode can be divided into solo driver auto, carpool auto, chauffeured auto, and specific local transit service options. Types of service can be divided into local feeder, local line-haul, and express line-haul, and further divided into individual routes, and beyond that into route segments. Time of day can be refined into the four Project FARE categories (A.M. peak, midday, P.M. peak, night) or even further into hour, half-hour, or 15-minute segments within certain categories.

In general, it will be desirable to partition collected data into various target market categories, since most demonstrations will probably consist of specific innovations aimed at particular user groups. The decision as to whether to stratify collected data by operational and geographic categories depends on the nature of the project and thus will have to be made on a case-by-case basis. However, it is recommended that the minimum time of day stratification (peak.off-peak) be used for every measure, since many

transit system operating characteristies as well as general traffic conditions vary widely between peak and off-peak periods. The decision as to stratification of data collection within the peak period (i.e., morning vs. evening peak) and within the off-peak period (i.e., midday vs. nighttime) should be made in accordance with the time of SMD service operation throughout the day and the variability of travel conditions and other relevant factors between the different categories. It is important to note that the peak period may be a changing period depending upon distance from the CBD and type of transit system (e.g., in Minneapolis it was found that the peak period for corridor analyses had to be expressed as a function of distance from the CBD).

c. Grouping of Raw Data Into Class Intervals

Measure stratification can also refer to the grouping of raw data into intervals, with intervals determined before or after data collection. Whereas the first two forms of stratification involve collecting and reporting a measure separately for each category (e.g., change in travel time during peak periods, off-peak periods), this type of grouping produces a frequency distribution for the particular measure.

Survey data on traveler behavior, characteristics, and attitudes is a good example of pre-collection determination of intervals. For instance, comparisons of users and non-users of an SMD service can be made using distributions of such measures as age, income, auto availability, and attitudes toward transit, with the particular response categories of each measure having been determined beforehand. Appendix A contains recommended response categories for selected demographic and travel behavior measures, as well as sample questions and response categories for selected attitudinal data.

Reliability measures provide examples of intervals that can be determined after data collection. The difference between scheduled and actual arrival time at an access point would be collected in its raw form (i.e., each vehicle's time difference in minutes) but would be reported as a frequency distribution. It is recommended that the following minimum stratification of this measure be used:

% early
% on time (vehicles arriving within + or - 1 minute of scheduled time)
% late

The contractor should be aware of differences in transit company standards with respect to schedule adherence, and the potential impact on data collection and analysis procedures.

Vehicle delays due to breakdowns can be grouped according to the following minimum stratification:

% No delay (delay of 1 minute or less)
% Delayed
% Total disruption of service

If further detail is desired, the late category under schedule adherence and the delayed category under vehicle reliability can be divided into categories such as: 1-5 minutes delay, 6-10 minutes delay, over 10 minutes delay.

The basic intent of grouping is to summarize the raw data without masking the real form of the distribution for a given measure. In addition, the extent of grouping may also depend upon the specific analyses which are planned.

Interval grouping can be used in conjunction with either of the two forms of stratification previously discussed. For instance, person trip time can be stratified into components (access time, etc.), and time period (peak vs. off-peak); the values in each component in each time period can be grouped into 5 or 10 minute intervals to obtain a frequency distribution.

As was stated above, it is not possible in these guidelines to present a standardized approach to stratification for each measure. The contractor will therefore have to rely on judgment and past experience to determine which types of variable stratification are most likely to enhance the understanding of specific areas of demonstration effectiveness and potential application. The contractor should plan data collection activities with the finest stratification which can be justified as appropriate for the demonstration objectives. Since the ultimate sample size will be directly related to the number of categories employed, the contractor should make sure that the available sample units are sufficient to support the level of stratification deemed desirable. The Evaluation Plan developed by the contractor should contain justification for the type(s) and level of stratification selected, as well as

evidence that such stratifications are feasible from the standpoint of data and sample size availability.

3. Sampling Requirements

Once the contractor has determined the basic data collection/analysis design for the project evaluation and the type(s) and level of stratification for each measure, the final question to be addressed is sampling requirements.

In general, measures which are obtained from records (e.g., transit company cost and operating data) will be available on a continual basis over the entire lifetime of the demonstration project and will not require sampling. On the other hand, measures obtained from measurements, counts, and surveys will generally not be available on a continual basis but will have to be collected in the form of samples. There may also be situations where measurements or counts yield continual data (e.g., real-time traffic surveillance systems), but sampling is desired in order to reduce data processing expenses.

When collection of a particular measure involves sampling, an estimate of the minimum sample size must be made prior to the initiation of the data collection effort. In estimating sample size requirements, the objective is to have a large enough sample to be able to draw valid inferences about the population from which the sample is drawn. As might be expected, the determination of appropriate sample sizes involves trade-offs between the desired level of precision and the cost of data collection. These trade-off decisions in turn require a determination, during the evaluation planning phase, of the appropriate types of analyses to be performed (e.g., estimates of population parameters, comparisons between two or more groups of sampled data).

Appendix B presents specific guidelines relevant to estimating required sample sizes. Included in the discussion are: (1) references to statistics books containing sample size equations, (2) recommendations regarding values for the three input factors in the sample size equation; and (3) suggestions regarding implementation of the field data collection effort based on the calculated sample size values. Appendix B also contains a section on the basic types of statistical analysis which can be performed, and recommended confidence levels and reporting formats.

The contractor should follow the guidelines in Appendix B to develop appropriate sample sizes for each measure. The Evaluation Plan should contain the sample size values, along with an explanation of any assumptions or special procedures underlying these values (e.g., equations, input factor values used).

4. Timing of Data Collection

For measures based on sampling, another issue to be addressed by the contractor is the timing of data collection. The exact periods during which measures are collected has a significant effect on the validity and representativeness of evaluation results, since the operation and effectiveness of a transportation system are sensitive to various factors associated with time. Four basic questions arise concerning the timing of data collection:

(1) The appropriate season(s) of the year and day(s) of the week to include in the sample

(2) The appropriate duration of each data collection period

(3) The proper time to initiate data collection

(4) The appropriateness of "one-shot" vs. periodic monitoring.

The particular season(s) and day(s) depend largely on the assumed sensitivity of the demonstration technique or service to each time unit. If it is deemed appropriate to assess the impact of the SMD project under reasonably normal conditions, data collection should be performed during the fall and spring, when weather conditions are not severe, schools are in session, and few people are on vacation. To the extent that the demonstration evaluation involves measures related to travel patterns and transit usage, the contractor should attempt to schedule data collection activities during those two seasons which are most representative of normal conditions. On the other hand, if severe weather conditions or other atypical conditions are an inherent feature of the site and it is desirable to examine the SMD project under a full range of possible conditions, the contractor should schedule data collection throughout the year so the sample observations include extreme as well as normal conditions.

If a particular SMD service operates seven days a week, then the sample of days should include both weekdays and week-end days (in fact, the data should be stratified by weekday vs. week-end day to highlight the difference in service viability during these two periods). Regarding which day(s) to include in the weekday sample, similar logic applies as in the case of seasons. If the aim is to observe the project under typical weekday conditions, then any day(s) with abnormal traffic patterns should be avoided. In some cities, there is a difference between Monday and/or Friday conditions vs. Tuesday/Wednesday/Thursday conditions; if this is known to be the case for a particular demonstration site, then data collection should be scheduled for the three "typical" days rather than either of the atypical days. The contractor should consider the special characteristics of the demonstration and the site in deciding on which days are appropriate. If a large number of days are going to be involved, and there is no particularly significant distinction among days of the week, then a randomly selected sample of days would be preferable.

The duration of each data collection period should be determined based on the degree of day-to-day variability and on the required sample size. If the particular item being measured is suspected to vary in behavior from one day to the next, then the data collection period should include several days; if it has been determined that only Tuesdays, Wednesdays, and Thursdays can be used, then several weeks may be necessary to achieve the required sample of days. Moreover, if the sample size required for a particular variable is large, then several days of data collection may be appropriate to obtain the minimum sample of observations.

The choice of initiation time for each data collection period is dependent on a number of considerations, the chief one being that the "after" data collection not begin until the demonstration has settled in and stabilized. In general it will probably take a few months for a demonstrated technique or service to become fully operational, with all the "bugs" worked out, and possible behavioral influences associated with the innovation diminished or eliminated. The desire is to achieve a "steady state" for the system after the innovation has occurred. The time to achieve this "steady state" undoubtedly will vary from project to project. Thus data collection related to the operational phase of the demonstration should not commence until these adjustments and modifications are completed. Other factors determining the initiation date for data collection are the desire to avoid summer and winter months and the overall schedule of the demonstration project.

In most instances, data collection will be performed for discrete phases of the demonstration project -- i.e., before the project is implemented, while the project is operational, and possibly after the project is terminated.* However, if demonstration elements are by nature changing continually or if it is expected that the demonstration will cause gradual but continual changes in user- or operator-related measures, then a periodic process of data collection would be more appropriate than merely "before," "during," and "after" data collection. The multitude of data points obtained from a periodic monitoring process will make possible the examination of fuctional relationships either among measures of interest or in a time series. Moreover, monitoring of certain measures during the early months following introduction of the innovation(s) may be useful in determining when the effects have stabilized enough to initiate full-scale data collection. It should be noted that if periodic data collection is appropriate, then a sequential analysis procedure (similar to control charts) may be useful to permit reductions in sampling requirements.

The contractor's Evaluation Plan should indicate the exact timing of data collection for each measure involving sampling. This information should be presented in a schedule which also shows the projected implementation dates for the various elements of the project.

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*Post-demonstration data collection would only be performed if there was a desire to see whether operation of the demonstration technique or service for a limited period had led to permanent changes in people's travel patterns or attitudes.

CHAPTER IV

GUIDELINES FOR PERFORMING EVALUATION ACTIVITIES

This chapter presents suggestions relative to implementing the evaluation of an SMD demonstration. During the evaluation implementation phase of the demonstration evaluation process, data collection/analysis relating to site characteristics, quantitative measures, and qualitative measures is undertaken according to the plans and procedures laid out in the Evaluation Plan. In addition, information is gathered relative to the project's operational history and exogenous events which may have some bearing on the project outcome. This information is eventually incorporated into the analysis and interpretation of project results.

Contractor functions during the evaluation implementation phase include monitoring and/or performance of data collection activities, data reduction and analysis, subjective analysis of information relative to project issues, and synthesis of project findings into a Final Evaluation Report. In accordance with these contractor functions, this chapter of the guidelines is organized into two sections: (1) monitoring/performance of data collection; and (2) data reduction, analysis, and presentation. The recommended content and organization of the various contractor reports prepared during this phase are presented in Chapter V.

During this phase, the contractor must maintain a sensitivity to the relationships among the organizations involved in the project -- in particular, the grantee, UMTA, and TSC (see Chapter II, Section A). The contractor must work closely with these groups at the appropriate times, while maintaining the role and perspective of an external, objective organization assessing the impact of the demonstration.

A. MONITORING/PERFORMANCE OF DATA COLLECTION

Since much of the data required for SMD evaluations will be unavailable from pre-existing data bases and secondary sources, each demonstration will undoubtedly involve significant data collection efforts. Given the considerable amount of time and money which will be spent on

data collection, careful management and overseeing of the data collection process is essential.

The contractor is responsible for seeing that data collection is performed according to the TSC/UMTA-approved Evaluation Plan. There are three potential alternatives associated with data collection. One of these occurs when the grantee collects all data (under SMD and/or local funding), and the contractor acts in a monitoring role to assure the quality and timeliness of data collected, as well as adherence to procedures laid out in the Evaluation Plan. A second alternative occurs when the contractor collects all the data, and coordinates the timing and performance of these activities through the grantee. The third and most likely possibility is one in which both grantee and contractor collect various elements of the data.

In order to monitor and/or perform the data collection activities called for in a given evaluation, the contractor will need to maintain open channels of communication with the site, in the form of visits, telephone contact and written correspondence with the appropriate local agencies, as well as subscriptions to local newspapers. Where day-to-day contact with the site is necessary, the contractor should arrange to base a member of the firm at the site.

Whether data collection is being performed by the contractor or by the local grant recipient, the contractor must stay closely involved in all phases to make sure that the procedures specified in the Evaluation Plan are followed. In cases where the grantee or other local agency is collecting data, the contractor should meet frequently with the agency to discuss progress and problems, work out solutions to the problems, and observe key phases of field data collection. In addition, the contractor should occasionally perform independent spotchecks, especially in the case of measures for which the local agency has limited experience in data collection.

The contractor is expected to inform TSC of the status of data collection in its Monthly Evaluation Progress Reports (see Chapter V for the recommended content and organization of this type of report). Should there be any unacceptable degradation of quality or timeliness of data collected by the grantee, the contractor should notify TSC in writing. TSC will in turn take steps through the UMTA Project Manager to rectify the situation.

Over and above monitoring data collection activities, the contractor should keep abreast of the status of the demonstration project. This awareness of project

operational status is important so that (1) data collection activities can be smoothly coordinated with ongoing project activities (causing miminum disruption of day-to-day operations) and (2) so that evaluation results can be interpreted in the context of project history. The grantee's Quarterly Project Progress Reports to UMTA/TSC (see Chapter V for recommended content and organization) will be a useful source of information on the project's operational evaluation. However, the contractor is encouraged to obtain a more detailed account of progress/problems relative to implementing and operating the demonstration by talking with the grantee at the site.

In addition to keeping abreast of project operations, the contractor should be continually watching at the site for unexpected (exogenous) events which might affect the validity of project results. In any implemented demonstration, no matter how well controlled or planned, the possibility remains for unexpected events to occur that may have an impact on measures of the project's performance. These unexpected occurrences are classified as threats to the validity of the demonstration.

Unanticipated developments at the site can take the form of temporary events such as a parking lot attendant strike or longer-term phenomena such as the closing of a major thoroughfare. The following are examples of unexpected factors that have been experienced in earlier demonstration projects, along with an indication of the compensatory action taken to counteract the exogenous event:

Changes in employment. There were thousands of unemployed in Seattle (Blue Streak Project) due to the high number of layoffs in the aerospace industry. (No compensatory action was taken.)

Changes in freeway traffic volumes. Shirley Highway experienced a shift from arterials to the freeway upon completion of new lanes and sections. Minneapolis, on the other hand, noted a shift to the freeway due to arterial street constructon and land developments within the project. Seattle's "Blue Streak" noted volume shifts on the entrance and exit ramps where new lanes had been added or preferential treatment was given to buses. Seattle also experienced a queuing problem onto the freeway from autos that were diverted from converted ramps. (An adjustment in queuing sequence was made where necessary.)

The national energy crisis. Minneapolis experienced a drastic change in traffic volumes from auto to transit during the energy crisis. Although it cannot be determined whether the shift in volumes was directly attributable to this factor, the timing of the initiation of the project during this period may have had some impact on data interpretation. (Extended routes and an increase in the frequency of service were the immediate modifications made to facilitate transporting such large number of people. Also, their marketing campaign was modified -- slowed down -- in view of the large numbers.)

As previously noted, the use of a test-control evaluation design will in certain cases mitigate the impact of these unplanned events on the validity of the project results.

The contractor is responsible for informing TSC of any unplanned phenomena which arise during the course of the evaluation. The contractor's Monthly Evaluation Progress Report should describe the potential effects on validity of any phenomena noted, as well as propose changes in the project and/or evaluation to compensate for the unplanned occurrences.

Although data collection should generally proceed according to the Evaluation Plan, there may be instances where modification to the originally planned procedures is warranted. The previous paragraph indicated that exogenous events at the site might be cause for modifying the evaluation. Two additional reasons for deviating from the planned approach are discussed below, namely, operational changes in the project, and availability of improved evaluation techniques.

Operational changes in the project can come about as a result of contractor recommendations (transmitted in the Monthly Evaluation Progress Reports) or decisions by UMTA and the grantee. Whatever the impetus for these changes in the scope or operation of the demonstration, the evaluation will have to be modified accordingly. The contractor is responsible for assessing the impact on the evaluation of any forthcoming or proposed operational changes, and recommending appropriate modifications of the Evaluation Plan to TSC.

As new data collection techniques are developed in the course of the SMD program, it may be appropriate to modify certain aspects of a project's Evaluation Plan. The contractor will have to assess, on a case-by-case basis, whether the potential benefits of the new techniques are

sufficient to justify modification to the planned evaluation activities, and then recommend the appropriate course of action to TSC.

In order to further the state-of-the-art of transit demonstration evaluation, the contractor is responsible for performing an ongoing assessment of data collection procedures used. It should be fairly evident that no attempt has been made in past demonstrations to record in a consistent manner information on how well the method worked. The evaluation contractor should maintain close control over data collection procedures used and summarize findings with respect to each technique. These findings will include, as a minimum:

(1) A narrative description of how the collection procedure was planned and implemented.

(2) An indication of areas in which the technique outperformed expectation.

(3) An indication of areas in which the technique was deficient.

(4) If available, some summary of the inherent variability in collecting project measures due to the technique itself, as opposed to variability due to other demonstration factors.

(5) Actual cost for implementing the technique, including capital costs, and all operating and support costs.

(6) Where two techniques have been employed to collect the same basic measures, cross-comparisons and a recommendation as to which technique should be used in similar future demonstrations.

This information will ultimately be incorporated into an Appendix of the Final Evaluation Report.

B. DATA REDUCTION, ANALYSIS AND PRESENTATION

The contractor is responsible for performing all data reduction and analysis, regardless of which agency has collected the data. Data reduction involves the processing of raw data, either manually or using a computer, to yield statistics such as means, standard deviations, ratios,

ranges, and frequency distributions. The specific statistic to be calculated from the raw data will depend on the type of measure and type of comparison involved. A few examples are given below. Quantitative measures such as travel time and vehicle passenger counts will be processed into average values for each level of stratification used. If a comparison of two time periods is involved, the percentage change from the earlier to the later period will be calculated. Quantitative measures relating to schedule dependability will be summarized into average values as well as standard deviations, with comparisons calculated as ratios of standard deviations. Qualitative measures obtained through surveys will be handled to yield frequency distributions for the response categories.

Data reduction may involve the use of statistical inference techniques. If the data is based on a 100% data collection effort (i.e., no sampling), then exact values of the statistics listed above can be calculated. However, if the data has been obtained by sampling (as will usually be the case), results cannot be presented as precise values, since there is a certain probability that the calculated values are different from the true population values. It is recommended that data based on samples be processed into two-sided confidence intervals using two confidence levels: α=.01 and α=.05. Appendix B presents further guidelines relative to calculating confidence intervals.

The contractor should arrange for smooth transfer of collected data from the collection site (e.g., buses, transit company, roadside stations) to the processing site. Special attention should be paid to details such as labeling and dating of forms, tapes, etc. to make sure that valuable data is not lost or altered.

The basic data which is collected during a demonstration project should be maintained either on punch cards or other appropriate storage devices (e.g., magnetic tape). While the raw data may not be immediately utilized, it should remain with the contractor (or eventually TSC) for potential future uses.

Data analysis involves the interpretation and synthesis of the processed data and other information to draw conclusions relative to the attainment of project objectives and issues, and relative to project transferability. Statistics such as means and frequency distributions are carefully examined and pulled together to obtain a comprehensive, in depth understanding of the effects of the demonstration, and the underlying reasons for observed changes. The contractor must apply sound judgment as well

as knowledge and experience relative to transit system operations, traffic operations, and travel behavior in order to interpret the collected data and place it in proper perspective. To the extent possible, the results of the demonstrated innovations in the demonstration site should be supplemented by an assessment of the influence of site-specific and exogenous factors on project outcome, so that conclusions can be made regarding the potential applicability and effects of implementing the demonstration in other sites across the country. In order to further enhance project transferability, the analysis/synthesis phase should provide a compilation of lessons learned regarding the operation of the demonstration.

The contractor should understand and be aware of the importance that the use of appropriate statistical techniques can attach to the analysis and interpretation of project results. In view of the fact that most aspects of an urban transportation system tend to be dynamic and variable from hour-to-hour, day-to-day, and month-to-month, observed differences could be attributable only to this inherent variability and not to the SMD innovations. Furthermore, factors other than the planned and controlled innovations could also be directly related to the observed changes in those measures being collected. It is important to note that while no single technique exists for removing the potential influence of these exoqenous factors, it is possible, by careful analysis, to at least point out the occurrence of such events and create an awareness for those who review the project's conclusions and/or recommendations. Hence, it is important to be able to specify whether the observed differences in, for example, travel time are within reasonable bounds of expected variability inherent in the given transportation system, or whether the observed differences cannot be accounted for just by system random variability. If the latter case were true, taking into consideration the potential external influencing factors, one could conclude that the innovation has in fact provided a real change in the measures being considered. It is to this capability for making valid inferences that the specific statistical techniques apply.

Presentation of project results in Annual Project Status Summaries, Interim Evaluation Reports, and Final Evaluation Reports should be in the form of quantitative and qualitative exposition, with exhibits such as tables, graphs, and bar charts serving as the focus for narrative discussion. In no instance should there be an excessive narrative describing all the elements of an exhibit. This tends to be redundant and masks the really important findings.

Chapter V provides some guidance relative to overall content and organization for the aforementioned reports. With respect to the format for exhibits, creative techniques for displaying information are encouraged, so long as the information is presented in a clear and accurate manner. In order to provide the contractor with some indication of the types of exhibits that are acceptable, some examples from recent projects are presented on the following pages.

Exhibits 11-17 are clear and informative. While they do not present detailed information, they are useful in highlighting the project findings appearing in an executive summary, which is designed to convey rapidly to the decision-maker the significant conclusions of the project. Back-up exhibits which contain significantly more detail will be contained within the body of the evaluation report or in technical appendices. Exhibits 18-22 fall into this category.

The contractor should attempt to perform data reduction and analysis as data is collected, so that interim results are available throughout the project evaluation. These interim findings will not only satisfy general curiosity regarding the project's effects, but will also provide feedback information relative to ongoing project operations and evaluation. Examination of preliminary evaluation results may suggest opportunities for modifying the project and/or evaluation procedures so as to increase the utility of the demonstration projects.

EXHIBIT 11

DIAGRAM SHOWING THE SERVICE AREA FOR

THE SEATTLE BLUE STREAK PROJECT

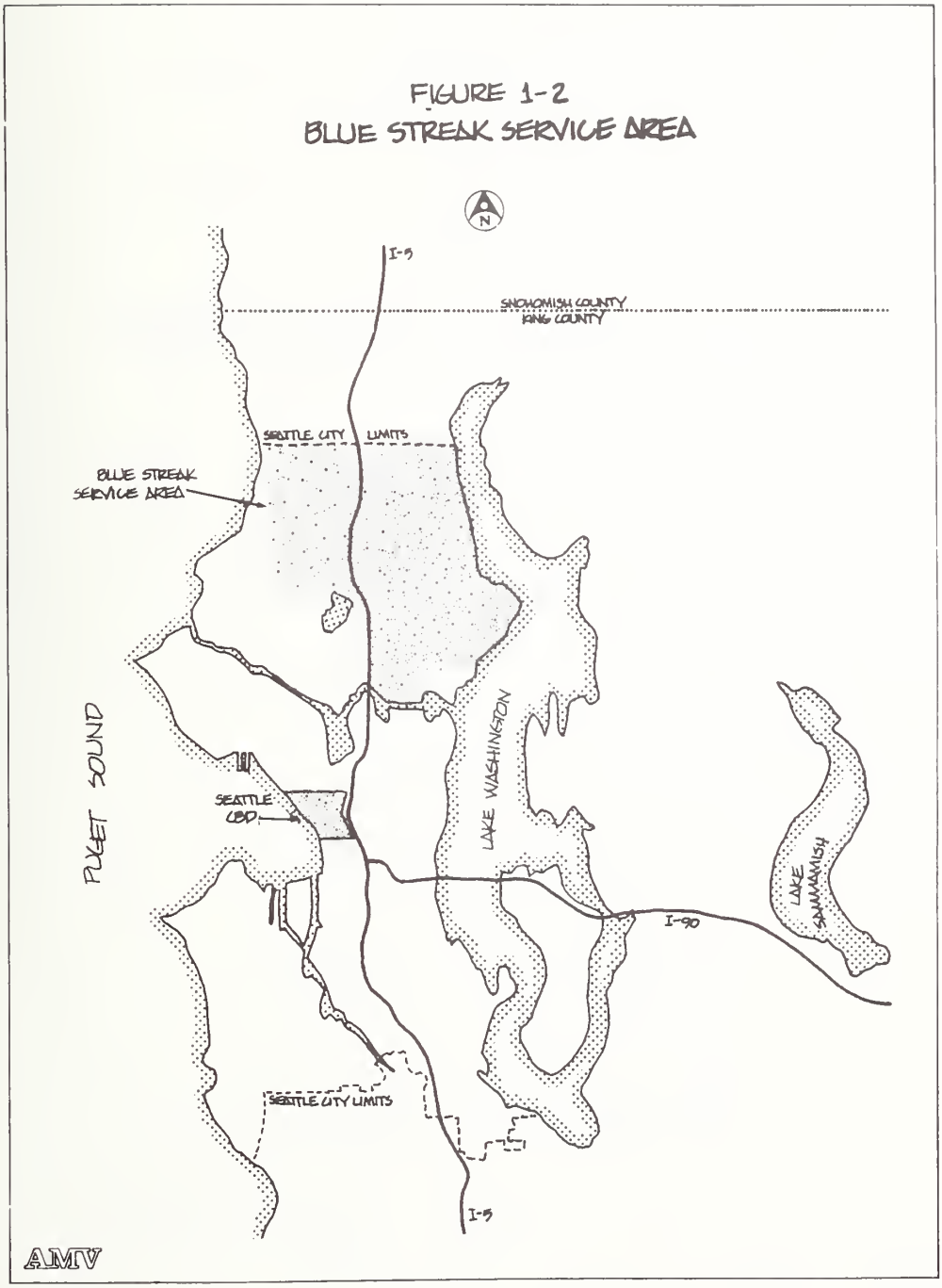

EXHIBIT 12

SCHEMATIC SHOWING HIGHWAY RAMP VOLUMES
FOR THE SEATTLE BLUE STREAK PROJECT

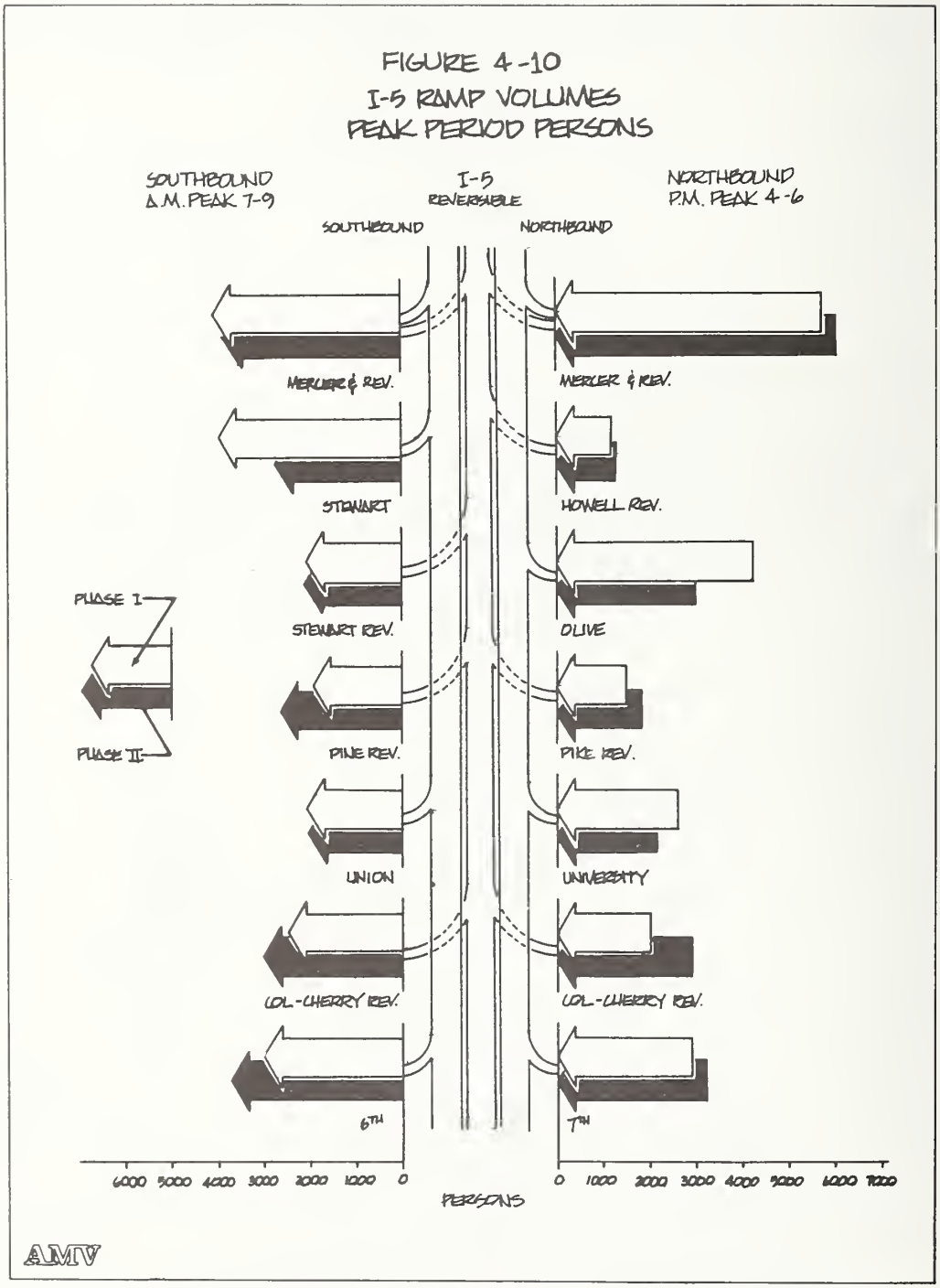

EXHIBIT 13

DIAGRAM SHOWING DISTRIBUTION OF PARK-AND-RIDE USERS FOR THE SEATTLE BLUE STREAK PROJECT

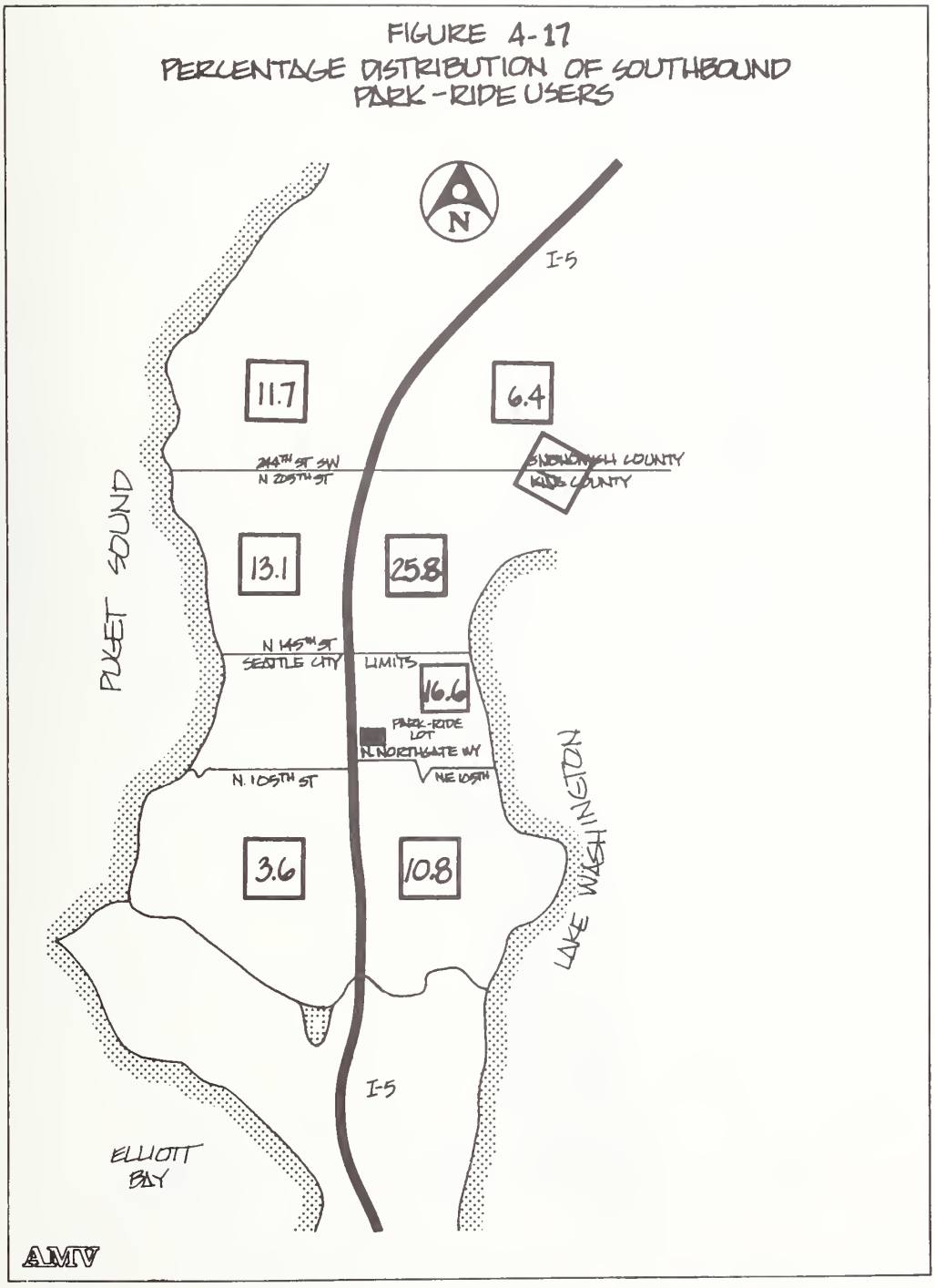

EXHIBIT 14

SCHEMATIC SHOWING PASSENGER VOLUME FOR THE
SEATTLE BLUE STREAK PROJECT

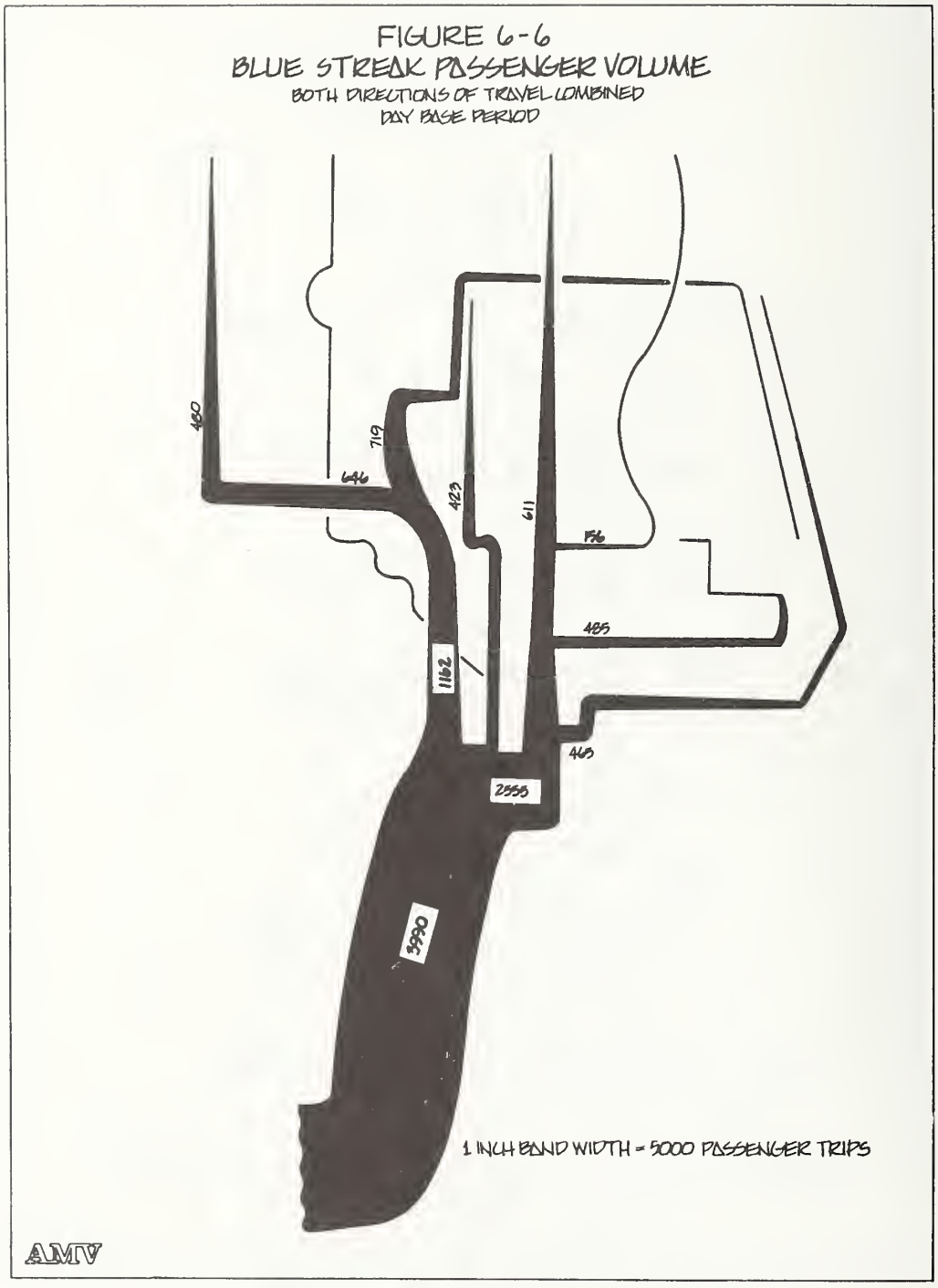

EXHIBIT 15

BAR CHARTS SHOWING BUS SCHEDULE ADHERENCE FOR THE MINNEAPOLIS URBAN CORRIDOR PROJECT

FIGURE D-5:
I-35W EXPRESS SOUTHBOUND - PM SCHEDULE ADHERENCE FOR MTC DOWNTOWN SERVICE

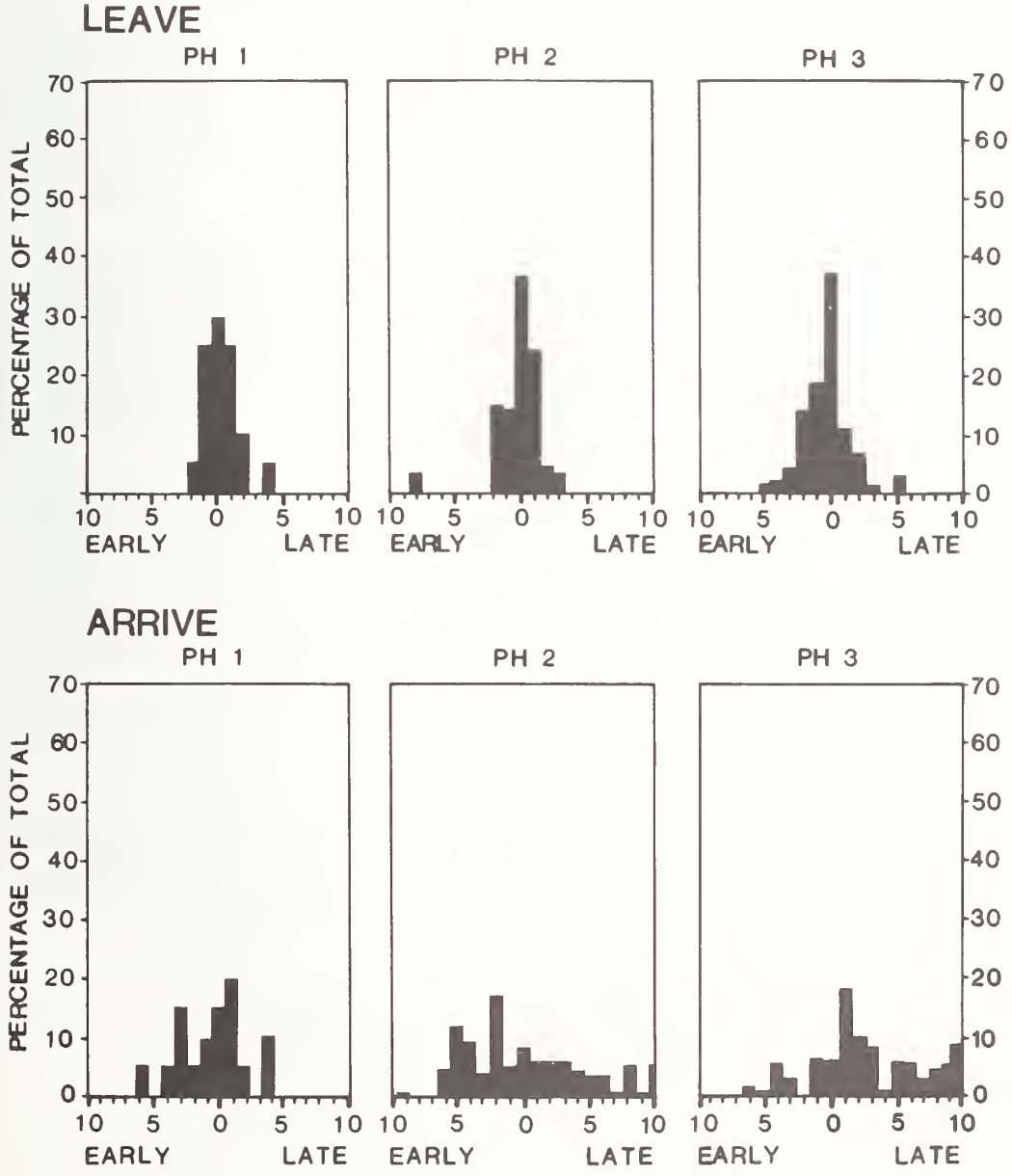

EXHIBIT 16

BAR CHARTS SHOWING CORRIDOR BUS AND AUTO VOLUMES FOR THE MINNEAPOLIS URBAN CORRIDOR PROJECT

FIGURE A-3: CORRIDOR VOLUMES BY VEHICLE CLASSIFICATION

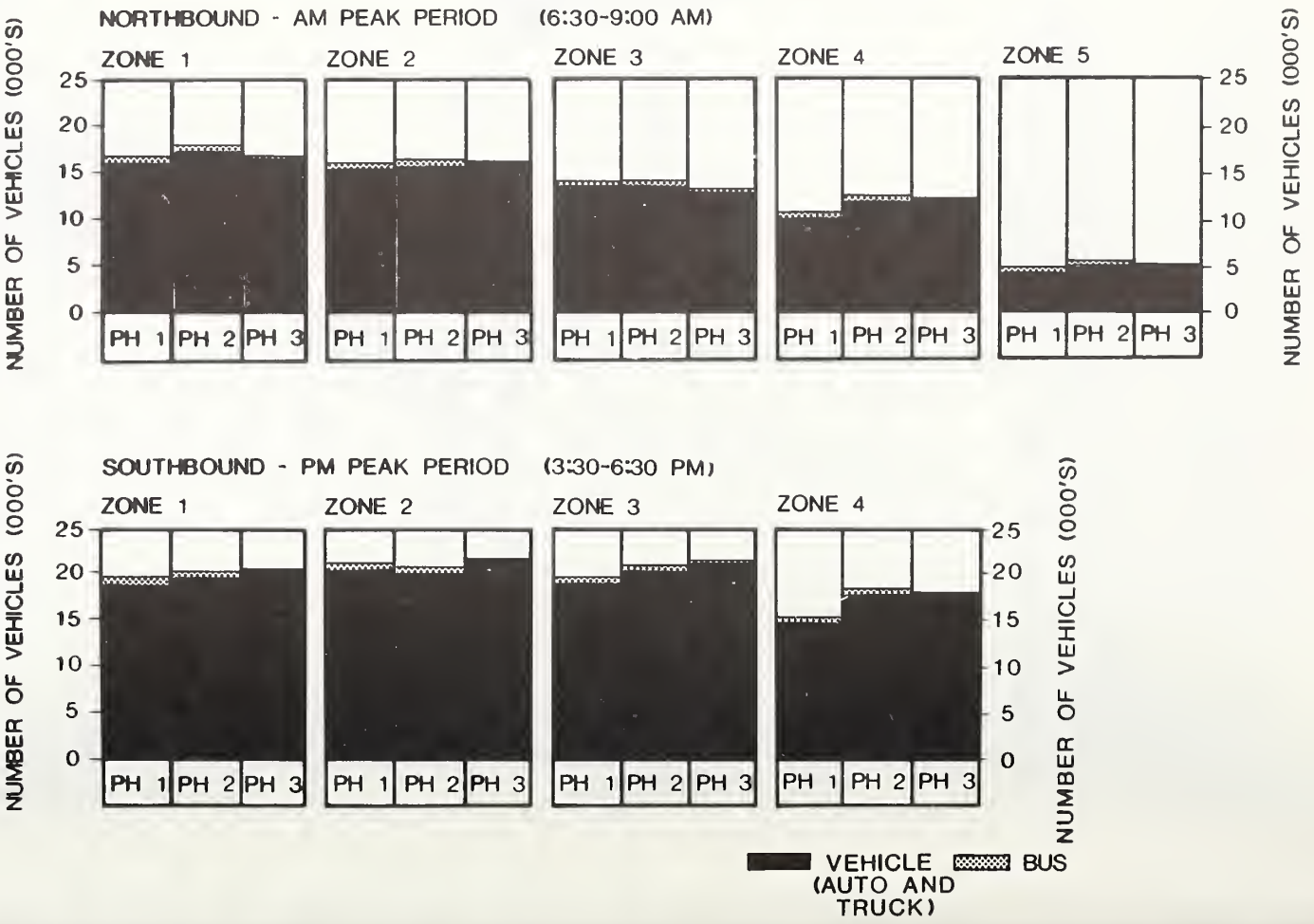

EXHIBIT 17

GRAPH SHOWING TRENDS IN BUS UTILIZATION FOR THE SHIRLEY HIGHWAY EXPRESS-BUS-ON-FREEWAY PROJECT

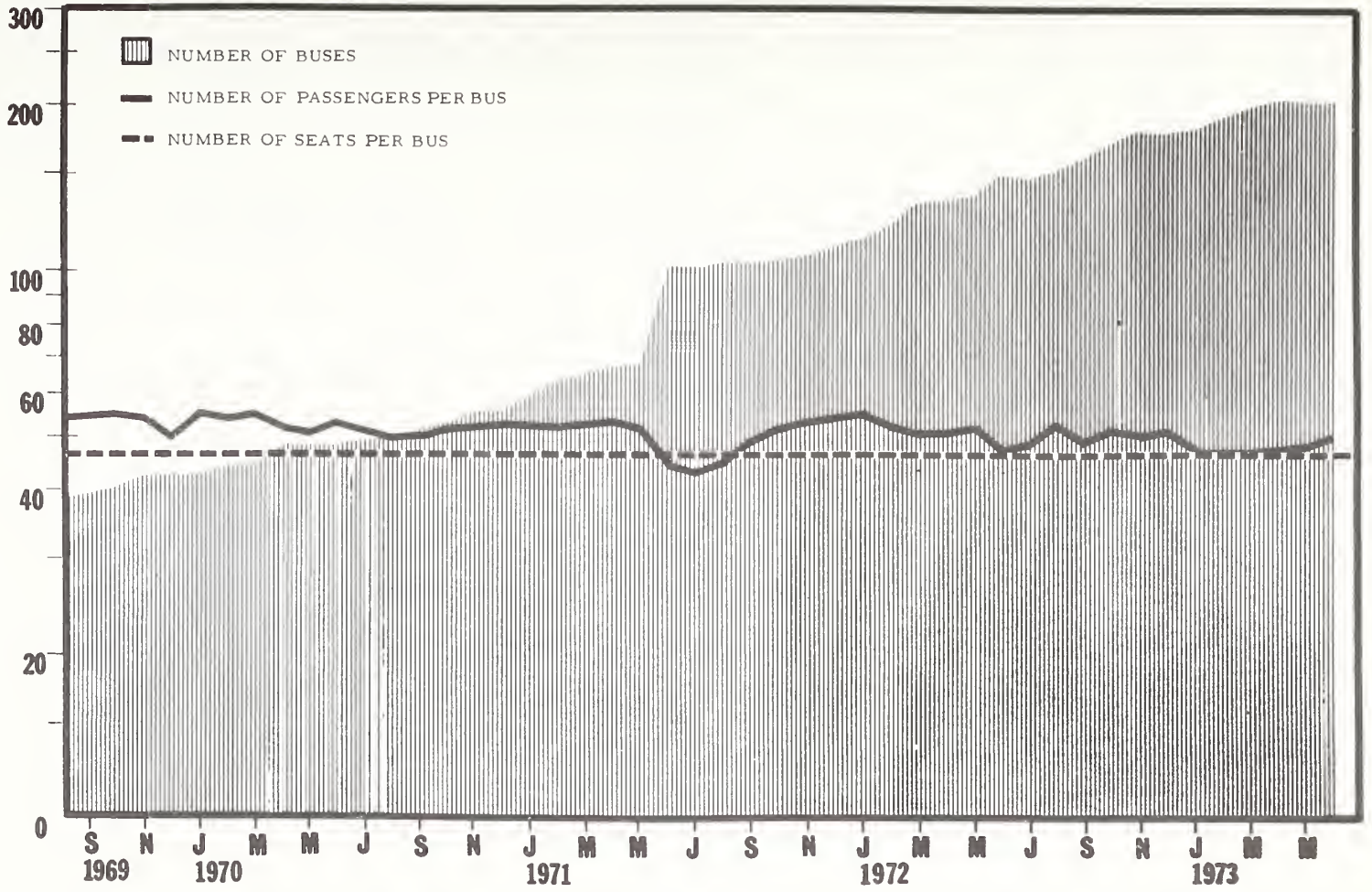

EXHIBIT 18

TABLE SHOWING CORRIDOR DEMOGRAPHIC CHARACTERISTICS FOR THE SHIRLEY HIGHWAY EXPRESS-BUS-ON-FREEWAY PROJECT

	TOTAL CORRIDOR		WITHIN 1 MILE		BETWEEN 1&2 MILES		WEST REMAINDER		EAST REMAINDER	
	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT
POPULATION										
Total	496,470	100	132,945	26	93,861	18	149,607	30	120,057	24
Negro	32,379	7	10,919	8	5,536	5	1,916	2	14,008	12
Number Families	167,564		47,832		32,079		46,389		41,264	
AREA										
Square Miles	152.6		42.6		30.3		49.5		30.1	
Population Density per Sq. Mile	3,253		3,120		3,097		3,022		3,988	
YEAR MOVED INTO HOUSING										
1968-1970	73,871	47	24,725	56	13,392	45	19,668	45	16,086	42
1965-1967	35,147	22	9,786	22	6,687	22	10,178	23	8,496	22
1960-1964	24,117	15	5,575	13	4,320	14	7,933	18	6,287	16
1950-1959	17,922	11	3,378	7	4,201	14	5,171	12	5,172	14
1949 or earlier	5,764	4	1,011	2	1,304	4	1,145	2	2,304	6
CLASS OF WORKER										
Private	110,666	52	30,282	51	21,621	53	30,926	50	27,837	55
Government	78,708	37	23,260	39	15,038	37	23,139	38	17,271	34
Local Government	16,372	7	4,370	7	2,721	7	5,264	9	4,017	8
Self-employed	6,788	3	1,417	2	1,189	3	2,340	3	1,842	3
Total	212,534	100	59,329	28	40,569	19	61,669	29	50,967	24
AUTOS AVAILABLE										
1	74,497	44	25,000	53	14,327	44	17,569	37	17,601	41
2	60,004	36	14,488	30	10,963	34	21,261	46	13,292	32
3 or more	9,680	5	1,947	4	1,851	6	3,607	7	2,275	5
Total (Autos)	223,545		60,617		39,955		10,912		51,010	
Average (Autos/family)	1.34		1.27		1.25		1.53		1.24	
None	25,179	15	6,291	13	4,518	14	4,815	10	9,555	22
MEANS TRANSPORTATION TO WORK										
Driver	147,958	69	41,186	68	27,647	66	44,972	73	34,153	67
Passenger	30,186	14	8,763	14	6,155	15	8,164	13	7,104	14
Total Autos	178,144		49,949		33,802		53,136		41,257	
Bus	21,906	10	6,633	11	5,096	12	4,448	7	5,729	11
Walked to work	7,965	4	2,070	3	1,334	3	2,079	3	2,482	5
Worked at home	3,352	2	881	1	622	1	1,059	2	790	1
Other	4,107	2	1,092	2	844	2	1,113	2	1,018	2
WORK PLACE										
D.C.-Central Business District	20,095	9	5,973	10	3,967	10	5,920	9	4,235	8
D.C. Remainder	38,259	18	11,536	19	8,079	19	10,331	17	8,313	16
Arlington	40,114	19	11,569	19	8,844	21	13,168	21	6,533	13
Virginia Remainder	88,847	41	23,885	39	15,935	38	24,624	40	24,403	48
Other	28,241	13	7,688	13	4,924	12	7,812	13	7,817	15
Total	215,556	100	60,651	28	41,749	19	61,855	29	51,301	24

[a]Refer to Figure 2 in paragraph 2.3.3.

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing: 1970 Census Tracts PHC (1)-226, Washington, D.C.-Md.-Va. SMSA, May 1972.

EXHIBIT 19

TABLE SHOWING PROJECT OPERATING STATISTICS FOR THE SHIRLEY HIGHWAY EXPRESS-BUS-ON-FREEWAY PROJECT

Table 11

Project Operating Statistics - Last Half 1971 (30 Bus Fleet)

ROUTES	TOTAL DAILY MILES[1]	REVENUE TRIP DISTANCE (MILES)[2]	DAILY REVENUE TRIPS[3]	DAILY PASSENGERS	RUNNING SPEED (MPH)[4]	PASSENGERS PER MILE[1]	PASSENGERS PER TRIP	REVENUE PER PASSENGER	REVENUE PER MILE[1]	COST PER MILE[1]
Peak										
2G	338	18.8	11.0	340	17.31	1.00	30.9	$ .73	$ .73	$ .95
4G, H	258	15.4	8.6	494	19.30	1.91	57.1	.70	1.34	1.07
6G	153	10.4	8.6	352	14.58	2.30	40.7	.60	1.38	1.29
7G	344	11.9	15.8	784	16.68	2.27	49.5	.62	1.48	1.14
8G	203	11.5	10.0	340	15.56	1.67	34.0	.60	1.00	1.15
17G, H, Y	420	20.8	10.6	491	20.97	1.17	46.1	.80	.92	.82
18G, M, X	469	19.7	13.5	647	19.75	1.39	47.9	.80	1.11	.82
19G	132	13.8	6.0	260	13.88	1.97	43.4	.65	1.28	1.40
	2312[T]		84.1[T]	3708[T]	17.4[M]	1.60[M]	44.14[M]	.70[M]	1.12[M]	1.01[M]
Base										
1A, B	431	26.1	16.0	75	12.97	.17	4.73	.41	.07	.52
17G, H	365	23.2	15.0	68	16.21	.18	4.54	.72	.13	.45
18G	362	22.1	15.0	127	15.56	.35	8.53	.71	.25	.47
	1159[T]		46.0[T]	270[T]	14.6[M]	.23[M]	5.86[M]	.61[M]	.15[M]	.48[M]

EXHIBIT 20

TABLE SHOWING DEMOGRAPHIC CHARACTERISTICS OF AUTO USERS FOR THE MINNEAPOLIS URBAN CORRIDOR PROJECT

TABLE B-13: DEMOGRAPHIC CHARACTERISTICS OF AUTO USERS

Characteristics	Arterial Auto User			I-35W Auto User		
	PH1 %	PH2 %	PH3 %	PH1 %	PH2 %	PH3 %
Sex						
female	48	49	46	36	36	31
male	52	51	54	64	64	69
Age						
under 21 yrs.	5	5	5	3	4	3
21 39 yrs.	52	51	53	55	56	56
40 - 64 yrs.	39	40	38	40	39	40
65+ yrs.	4	4	4	2	1	1
Income						
under $4999	6	5	4	2	1	1
$5000 - 9999	25	26	22	15	13	9
10000 - 14999	30	27	22	24	20	17
15000 - 29999	28	33	39	44	49	53
30000+	11	9	13	15	17	20
No. of Autos						
0	4	4	3	2	1	0
1	55	51	48	37	36	33
2	33	36	40	51	51	54
3+	8	9	9	10	12	13
Length of Address						
under 11 mos.	21	21	21	18	17	17
1 - 2 yrs.	23	22	23	21	23	24
3 - 4 yrs.	12	10	11	15	13	13
5 - 10 yrs.	16	19	18	22	22	21
11 yrs. +	28	28	27	24	25	25

EXHIBIT 21

TABLE SHOWING HIGHWAY TRAVEL TIME DISTRIBUTIONS FOR THE MINNEAPOLIS URBAN CORRIDOR PROJECT

TABLE A-10:
I-35W SOUTHBOUND PM PEAK PERIOD STATISTICAL SUMMARY

Link	Mean Travel Time (min)			Mean Speed (mph)			Travel Time Comparison[1]		Travel Time Variance			Comparison of Standard Deviation		Sample Size		
From – To	PH1	PH2	PH3	PH1	PH2	PH3	PH1/PH2	PH2/PH3	PH1	PH2	PH3	PH1/PH2	PH2/PH3	PH1	PH2	PH3
10th - 35W Merge	1.70	1.72	1.46	36	36	42	NS	NS	1.24	3.28	0.69	S	S	180	190	209
35W Merge - Lake	0.75	0.87	0.81	52	45	48	S	NS	0.07	0.17	0.09	S	S	180	190	210
Lake - 42nd	1.81	2.36	2.09	50	38	43	S	S	0.77	1.82	1.06	S	S	180	190	210
42nd - 50th	1.40	1.69	1.50	43	36	40	S	S	0.52	1.18	0.34	S	S	180	190	211
50th - 60th	1.65	1.58	1.63	41	43	42	NS	NS	1.94	0.68	0.34	S	S	180	196	215
60th - RR	1.02	1.02	1.08	44	44	42	NS	S	0.05	0.06	0.05	NS	NS	180	196	215
RR - 66th	1.39	1.43	1.45	51	50	49	NS	NS	0.02	0.03	0.01	S	S	179	196	217
66th - 90th	3.30	4.36	3.28	53	40	53	S	S	1.34	16.53	0.12	S	S	178	196	217
90th - 98th	1.70	2.38	1.45	28	20	33	S	S	1.21	6.09	0.35	S	S	145	194	217
98th - River	2.09	2.62	1.98	51	41	54	S	S	0.54	2.03	0.44	S	S	140	194	215
River - TH 13[2]	–	2.04	1.99	–	51	52	–	NS	–	0.24	0.44	–	NS	–	53	203
10th - River	16.87	19.81	16.67	45	38	46	S	S	22.84	75.06	9.18	S	S	140	194	214

[1] Significant or Not Significant

[2] Not surveyed in Phase 1

EXHIBIT 22

TABLE SHOWING PROJECT OPERATING STATISTICS FOR THE SEATTLE BLUE STREAK PROJECT

PASSENGERS PER MILE AND REVENUE AND COST PER MILE RATIOS

Blue Streak Routes	AM Pass/ Mile	AM Rev/ Pass	AM Cost/ Pass	BASE Pass/ Mile	BASE Rev/ Pass	BASE Cost/ Pass	PM Pass/ Mile	PM Rev/ Pass	PM Cost/ Pass	DAILY Pass/ Mile	DAILY Rev/ Pass	DAILY Cost/ Pass
5	2.32	$0.32	$0.60	1.77	$0.32	$0.35	3.18	$0.30	$0.46	2.22	$0.31	$0.44
7 (15th)	2.71	0.33	0.46	2.84	0.30	0.25	3.34	0.33	0.44	2.94	0.31	0.35
7 (Lake City)	5.39	0.30	0.32	2.43	0.30	0.28	1.87	0.29	0.74	2.71	0.29	0.37
7 (View Ridge)	2.44	0.29	0.53	2.92	0.29	0.26	1.74	0.29	0.67	2.41	0.29	0.42
16	3.61	0.29	0.31	--	--	--	2.71	0.29	0.48	2.45	0.29	0.44
8*	3.85	0.29	0.37	2.75	0.27	0.26	5.09	0.27	0.29	3.50	0.28	0.29
22*	2.37	0.29	0.63	3.08	0.28	0.27	5.01	0.29	0.38	3.33	0.28	0.35
41*	2.35	0.35	0.48	0.82	0.34	0.65	2.29	0.35	0.58	1.53	0.34	0.57
	2.82	$0.31	$0.46	2.07	$0.30	$0.32	2.88	$0.31	$0.49	2.44	$0.30	$0.41
Local Routes												
5	4.03	$0.29	$0.36	4.06	$0.29	$0.18	3.82	$0.29	$0.37	4.00	$0.29	$0.26
7***	2.12	0.29	0.62	5.80	0.28	0.14	5.96	0.29	0.26	4.78	0.28	0.22
16	2.56	0.29	0.52	2.90	0.30	0.24	3.37	0.30	0.41	2.90	0.29	0.33
8**	3.89	0.28	0.38	1.68	0.28	0.41	2.84	0.28	0.54	2.44	0.28	0.43
22**	2.44	0.28	0.65	3.03	0.26	0.25	2.07	0.27	0.73	2.72	0.27	0.39
	2.95	$0.29	$0.47	3.85	$0.28	$0.19	3.91	$0.29	$0.38	3.65	$0.29	$0.29
Control Routes												
6	4.49	$0.30	$0.31	3.12	$0.33	$0.21	2.89	$0.32	$0.41	3.33	$0.32	$0.29
25	3.52	0.28	0.40	1.06	0.31	0.61	2.03	0.31	0.67	1.89	0.30	0.53
26	3.91	0.29	0.39	2.25	0.30	0.30	2.79	0.30	0.58	2.70	0.30	0.39
	3.90	$0.29	$0.37	2.04	$0.32	$0.32	2.50	$0.31	$0.54	2.56	$0.31	$0.39
ALL ROUTES COMBINED	3.03	$0.30	$0.44	2.56	$0.29	$0.27	3.04	$0.30	$0.46	2.78	$0.30	$0.36
*8/22/41 BS	2.59	$0.32	$0.48	1.76	$0.29	$0.36	3.38	$0.31	$0.43	2.31	$0.31	$0.42
**8/22/41 L	3.34	$0.28	$0.45	2.25	$0.27	$0.32	2.55	$0.28	$0.60	2.55	$0.28	$0.42

***COMBINED #7 LOCALS

FIGURE 6-9

CHAPTER V

RECOMMENDED CONTENT AND ORGANIZATION OF REPORTS

At various stages in the evaluation process, the contractor for each SMD demonstration project is responsible for submitting specific reports to TSC. These reports are an Evaluation Plan submitted prior to conducting the evaluation, Evaluation Progress Reports submitted monthly throughout the project, Annual Project Status Summaries submitted yearly throughout the project, Interim Evaluation Reports submitted periodically throughout the project (about once a year), and a Final Evaluation Report submitted at the conclusion of the project. The grantee for each demonstration project is currently responsible for submitting quarterly progress reports on project status. As appropriate, information in these reports will be included in the contractor's Monthly Evaluation Progress Reports.

This chapter presents recommendations on content and organization which will guide the contractor in the preparation of these reports. The suggested content and organization for the grantee's quarterly progress reports is also presented.

A. EVALUATION PLAN

The Evaluation Plan is written by the contractor to explain, in detail, how the evaluation of the particular demonstration project will be performed. The following is a summary of the suggested content and organization format for the Evaluation Plan.

(1) Overview of the demonstration project

- Planned project innovations
- Demonstration site
- SMD Program objectives addressed
- Other relevant project objectives/issues addressed
- Project history (events or studies leading up to demonstration)

- Project schedule
- Project funding (total demonstration costs by source of funding, demonstration capital costs by innovation)
- Project grant recipient/operating agency.

(2) Description of the demonstration evaluation

- Overview of basic evaluation design, constraints affecting development of the Evaluation Plan
- Timing of evaluation stages as related to project implementation schedule
- Site data collection plans and sources
- Quantitative measures, qualitative measures, and/or information to be collected in connection with each project objective and issue
- Proposed data collection/derivation and analysis technique for each measure
- Schedule of data collection activities associated with the evaluation, and identification of which organization (contractor, grantee, other local organization) is to perform each activity. Schedule should indicate submittal dates for any Interim Evaluation Reports and the Final Evaluation Report.

(3) Technical management and cost information

- Estimate of contractor person-hours by type of direct labor (e.g., project manager, junior analyst), task (i.e., evaluation plan preparation and updating, management and coordination of overall evaluation, data collection/monitoring of data collection, data reduction, data analysis, and report preparation), and evaluation stage.
- Estimate of contractor direct costs by category of cost (travel, computer, etc.), task, and evaluation stage.
- Estimate of total contractor evaluation costs (Note: detailed cost estimate showing hourly wage rates, overhead, and general and administrative expenses should be submitted along

with the Plan under separate cover.)

- Estimate of person-hours and costs for data collection to be performed by other organizations (by activity if possible).

To facilitate the incorporation of modifications, the Evaluation Plan should be submitted in looseleaf form. As modifications are made, each page will have the date of modification indicated. Modifications may result from the initial review of the Plan by TSC, UMTA, and the grantee or they may occur during the evaluation implementation phase. As an example of the latter situation, examination of interim findings may reveal certain gaps or redundancies in the originally planned data collection program. Other reasons for modifying the Evaluation Plan during the implementation phase might be operational changes in the project, unanticipated developments at the site, or discovery of an improved evaluation procedure. The mechanism for obtaining TSC approval to modify the Evaluation Plan procedures is described below under Monthly Evaluation Progress Reports.

B. MONTHLY EVALUATION PROGRESS REPORTS

The Monthly Evaluation Progress Reports are written by the contractor to keep TSC and UMTA abreast of the status of the demonstration project evaluation the contractor is performing. These reports are intended to be as brief as possible. The following is a summary of the suggested minimum content and organization for the Monthly Evaluation Progress Report.*

---

*Prior to the start of the project evaluation, when the contractor is getting familiarized with the project, it is recommended that the contractor write monthly Progress Letters describing initial contacts with the project.

(1) Review of evaluation activities during the past month. Evaluation-related problems encountered and actions taken to rectify them. Narrative highlights of project- and/or evaluation-related exogenous factors and other events which appear to be significant and might influence the evaluation of the project.

(2) Status of data collection and analysis activities that have taken place in the past month (performed by both grantee and evaluator). Any contractor documentation on preliminary results which have been generated in this area could be appended to the Progress Reports or could be submitted separately as special technical memoranda.

(3) An indication of whether the evaluation is proceeding according to schedule, and, if not, reasons for the departure. A brief discussion of anticipated activities to be covered during the succeeding report period. Forthcoming Interim Reports, if any.

(4) Comparisons of cumulative budgeted to actual expenditures. Estimate of costs to complete evaluation tasks.

(5) Recommendations for changes, if any, to the Evaluation Plan, and the reasons such changes are recommended. (TSC concurrence is needed before any changes to the Plan can be made.)

C. ANNUAL PROJECT STATUS SUMMARIES

Annual Project Status Summaries are written by the contractor for the sole purpose of furnishing TSC with a "snapshot" of the demonstration project at the specific point in time when the TSC annual report to UMTA is written. It is envisioned that this report should be easily prepared from the Evaluation Plan and the various monthly Progress Reports, special technical memoranda, and Interim Reports. The suggested content and organization for Annual Project Status Summaries are presented below.

(1) Overview of the project describing the site, the innovations, the SMD Program objectives addressed, and other relevant project objectives and issues addressed.

(2) Overview of the past history, present operational status, and duration of the project.

(3) Findings to date in terms of the SMD Program objectives and other relevant project objectives/ issues.

(4) Implications of the findings relative to national significance and to transferability to other locales.

The suggested length of these Status Summaries is 15 to 20 pages, with charts and photographs included to highlight the narrative descriptions. Explanations of analyses performed and analysis methodologies used are not needed.

D. INTERIM EVALUATION REPORTS

Interim Evaluation Reports are written periodically by the contractor to present interim findings relative to all or some of the demonstration project objectives and to evaluate those aspects of the project where it is applicable to do so. Although submitted to TSC, they are also meant for dissemination to a technical audience.

Interim reports should be written every 9 to 14 months. If the evaluation process is divided into distinct stages whose durations fall roughly within these time frames, then interim reports should be written at the end of each stage. If the stages are shorter, such that two or three stages are completed within the 9 to 14 month time frame, then interim reports should be written at the end of these break points. Otherwise, interim reports should be written annually, except that no interim report is needed at the end of the demonstration project. The suggested content and format for Interim Evaluation Reports are presented below.

(1) Executive Summary of the Report

(Should be capable of standing on its own and being published separately.)

(2) Project Overview

Description of the project innovations, the SMD Program objectives addressed, and other relevant project objectives/issues. Brief history of the operation of the project over

its life, the current status of the operation (at the end of this report period), and highlights of project-related exogenous factors and activities that may be significant enough to influence the project.

(3) Site Overview

Description of the site, presentation of pertinent site data, and highlights of site-related exogenous factors that may be significant enough to influence the project.

(4) Evaluation Overview

Description of the basic evaluation procedure, the timing of the evaluation stages, and which stages are being examined in the report.

(5) Project Results

Assessment of the project in terms of its attainment of relevant SMD Program objectives and other (local and/or national) project objectives; insight into project issues associated with operational feasibility and characteristics of the demonstrated innovation. (For some objectives and issues, no concrete statements can be made until the project is concluded.) Relevant data is analyzed and presented in the forms of charts, graphs, and/or narrative. (There will generally be a need to present data from earlier interim reports.)

(6) Implications Regarding Transferability

- Assessment of the influence of site-specific characteristics and exogenous factors on the direction of the demonstration.
- Lessons learned, to date, based on practical experience, relative to the implementation and operations of the demonstrated innovations.

(7) Appendix

More detailed tables, charts, etc., on project results.

E. FINAL EVALUATION REPORT

The Final Evaluation Report is structured by the contractor early in the demonstration project and completed at the conclusion of the project. Its purpose is to synthesize the findings relative to each of the demonstration project SMD Program objectives and other relevant objectives/issues into an evaluation of the overall project. Although submitted to TSC, it is also meant for dissemination to a technical audience. The suggested content and organization for the Final Evaluation Report are given below.

(1) Executive Summary of the Report

(Should be capable of standing on its own and being published separately.)

(2) Project Overview

Description of project innovations, the SMD Program objectives addressed, and other relevant project objectives/issues. Brief overview of the operation of the project over its life, and highlights of project-related exogenous factors and other events that have been significant enough to influence the project.

(3) Site Overview

Description of the site, presentation of pertinent site data, and highlights of site-related exogenous factors that may have been significant enough to influence the project.

(4) Evaluation Overview

Description of the basic evaluation procedure and the timing of evaluation stages.

(5) Project Results

Assessment of the project in terms of its attainment of relevant SMD Program objectives and other (local and/or national) project objectives; insight into project issues associated with operational feasibility and characteristics of the demonstrated innovation. Relevant data is analyzed and presented in the forms of charts, graphs, and/or narrative.

(6) Implications Regarding Transferability

- Assessment of the influence of site-specific characteristics and exogenous factors on the outcome of the demonstration.

- Lessons learned, based on practical experience, relative to the implementation and operations of the demonstrated innovations. Can include suggestions for project modifications in the demonstration site or for future applications in other locales.

(7) Appendices

- Project costs

- Data Collection: Site data, quantitative measures, and qualitative measures collected.

- Assessment of evaluation procedures employed -- e.g., effectiveness of particular survey approaches used, cost/accuracy of innovative data collection techniques.

F. QUARTERLY PROJECT PROGRESS REPORTS

The Quarterly Project Progress Reports are written by the grantee to keep UMTA/TSC abreast of the status of the demonstration project implementation for which the grantee is responsible. These reports can serve as useful input to the contractor's work. The following is a summary of the suggested minimum content and organization for the Quarterly Project Progress Reports.

(1) Review of demonstration project activities during the past quarter. Project-related problems encountered and actions taken to rectify them. Narrative highlights of exogenous factors and other events which appear to be significant and might influence the project. An indication of whether the project is proceeding according to schedule and, if not, the reasons.

(2) Status of planned data collection activities.

(3) Comparisons of budgeted to actual expenditures. Estimate of costs to complete project.

(4) Recommendations for changes, if any, to the conduct of the project, and the reasons such changes are recommended.

APPENDIX A

SURVEY EXECUTION AND DESIGN

1. INTRODUCTION

It is anticipated that the evaluation of every SMD project will require data that can be obtained only from surveys, and will therefore require some form of survey data collection. Among the possible survey respondents are SMD service users, auto users, service area residents who do not use transit, and transit company personnel. Typical survey objectives might include determining user and non-user characteristics, attitudes toward transit service, and past and present travel behavior; measuring modal shift; and assessing the experience of transit officials with regard to implementing a new technique. Although the specific contexts in which the surveys are conducted may differ, there is still a need for consistency of procedure in survey design and data collection to insure comparability of results.

In surveys, the researcher is collecting data from real life situations, which means that many unanticipated, spontaneous, and unusual situations will arise. To compensate for the survey researcher's lack of control of the experimental situation, the need for consistency and the establishment of general policies or guidelines to handle a great variety of possible developments is most important.

This appendix contains guidelines for use in formulating and carrying out surveys. It discusses how to define the populations to be sampled, i.e., the survey universes, describes how to select samples that will be representative of that universe, examines techniques for surveying the samples selected, presents suggestions as to survey content and format (including a list of standardized questions to serve as a basic set for most surveys), and discusses the problem of non-response bias.

A separate section at the end of this appendix contains guidelines for conducting interviews with transit company personnel, e.g., drivers, management, mechanics.

It should be stressed that this appendix presents no hard and fast rules which must be followed by each contractor. It merely guides the contractor in designing and executing surveys. In determining survey methodology, the contractor should consider potential alternatives and give the rationale for decisions made in terms of the survey

objectives, site characteristics, and any other relevant factors which have influenced the decision.

2. DEFINING THE SURVEY UNIVERSE

The first step in executing surveys is to define the survey universe, i.e., the groups about which the surveys are seeking knowledge. It is apparent that knowledge about project service users' travel behavior, characteristics, and attitudes toward transit is needed in an evaluation of project service. Moreover, an evaluation of project service will usually not be complete without some data on non-users, particularly to identify who they are and why they do not use the project service. Accordingly, there are two survey universes which will be relevant for SMD projects: users of the demonstration project service, and non-users of the project service. Users are defined as those who ride the project service at least occasionally but still on a regular basis (e.g., regularly twice a month). Non-users are defined as those using alternate modes (i.e., other than demonstration project vehicles) who make trips that could be made on the project service. In transit dependent demonstration projects, non-users could also be persons who could make trips using the demonstration project service but do not make these trips at all.

Occasionally, there will be a third survey universe of interest, the general population of the region in which a demonstration is being implemented. Attitudinal surveys of this universe will be used to obtain a profile of the community in which the demonstration project service is being provided. It should be apparent that many of the questions asked users, non-users, and the general population will be different.

Definition of the term demonstration project service area allows a more precise definition of non-users and the general population. The project service area is defined as the area that comprises on the order of 90 to 95 percent of the origins and destinations of the users of the demonstration project service. Since non-users are potential users, the origins and destinations of non-users should be comparable to those of users. Non-users can now be defined as persons not using the demonstration project service who make trips that begin in the origin portion of the service area and end in the destination portion of the service area at the same times as users make these trips. The general population in the region of the demonstration

project can now be defined as the population residing within the service area.

The demonstration project service area is usually not well defined at the outset of the project and must initially be estimated. In some demonstration projects, specifically demand-responsive projects, the origin and destination portions of the service area are given. At the other extreme, in demonstration projects where park-and-ride is a significant access mode, it may be impossible initially to estimate the service area accurately. A conservatively estimated area that includes all possible park-and-riders would have to be initially defined as the origin portion of the project service area. Once survey data on the origins of park-and-riders is obtained, a more accurate estimate of the service area can be made, and non-users can then be identified.

3. SAMPLING THE SURVEY UNIVERSE

The next step in executing surveys is selecting an appropriate sample for surveying users, and, where applicable, selecting appropriate samples for surveying non-users and the general population.

The purpose of sampling is to reduce the amount of data collection required. Rather than obtaining information from every member of the universe, the principles of sampling provide ways to obtain information from a very small portion of the universe. Sampling procedures also indicate the accuracy with which the characteristics of the universe have been represented.

A key assumption in sampling is that, prior to drawing a sample, the complete universe has been identified. Therefore, every member of that universe has a known probability of being selected for inclusion in the sample. The quality, or representativeness, of any sample is directly derived from the completeness of the identification of all members of the designated universe.

For these reasons, careful definition of the universe and selection of a source from which to draw a sample is very important. If the listing of the universe, or the sampling source, is biased through failure to include affected members, whether deliberate or random, the sample may magnify the bias and may not represent the universe.

A sample of users can be selected from among those onboard the transit vehicles or among those at transit collection points, i.e., stations, park-and-ride lots or transfer points. For demonstration projects in which all users are registered, e.g., demand responsive or subscription service, a sample can be selected from among the registration lists. For projects which serve specific employment or activity centers, e.g., handicapped and elderly service or subscription service, a sample can be selected at these centers.

Selecting a sample of non-users is considerably more involved than it is for users. While the user group is identifiable (and can be directly sampled), the non-user group cannot explicitly be identified before it is sampled.* A larger group must first be sampled, and then the trip origins and destinations of the survey respondents** examined in order to identify non-users (i.e., those whose trip origins and destinations are within the project service area). A definition of the project service area (as previously discussed) is a prerequisite for identifying non-users.

In demonstration projects where travel by users and non-users is in a specific direction through a corridor, as on the Shirley Highway project in Virginia or the I-95/N.W. 7th Avenue project in Miami, Florida, non-users, specifically auto users, can be sampled from license plate matches. A screenline is selected which intercepts the main arterials carrying autos between the origin and destination portions of the project service area. A sample of the license plate numbers of the autos crossing the screenline is recorded and a list of names and addresses of the owners of these autos is obtained from Department of Motor Vehicle records. This list (or a subset of this list) constitutes a sample in which a large percentage are project service non-users. Some of those crossing the screenline do not make trips that begin and end in the project service area, and are, therefore, not non-users. However, the entire sample

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*There may be SMD projects directed at carpooling. In this situation, carpoolers would be "users" as defined in this appendix. However, the population of carpoolers is not explicitly identifiable; therefore, it must be sampled by the same methods used for non-users.

**This information is requested in the survey.

must be surveyed because it is not known who the non-users are until the trip origins and destinations of all those in the sample who completed their surveys are examined. In certain very specific cases, samples can be selected directly from the traffic stream, e.g., at toll booths, at off-ramps, or from among carpoolers assembling at parking lots.

In demonstration projects where travel by users and non-users is not in a specific direction nor through a corridor, the non-user universe cannot be sampled using the above methods. In such cases, a sample may be drawn from households in the origin portion of the particular project's service area. Lists of households from which to select a sample could be obtained from utility records, insurance company records, census block statistics, telephone books,* property tax records, etc. Many of the people in these households do not make trips ending in the destination portion of the project service area, and are, therefore, not considered non-users. As previously discussed, the entire sample must still be surveyed because the non-users cannot be identified until after the entire sample is surveyed.

If the preceding method is used for obtaining a sample of non-users, it should be noted that the households selected constitute a sample in which a moderate percentage of the people are users. It may be desirable to identify users before they are surveyed (by asking all those sampled if they are users) in order to ask them questions pertaining to their use of the project service.

In all samples of households, an attempt is made in each household to survey only that individual in each household who makes a trip ending in or near the destination

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*Where the telephone book is used as the sampling source, there is considerable danger of obtaining a biased sample. About 20% of the population nationally, and up to 40% in large urban areas, choose to have unlisted telephones. Also, poor people are much less likely to have telephones, as are residents of boarding houses.

Random digit dialing not only poses potential bias problems but also will be costly because business and non-residential phones will be called up to 60% of the time in urban areas.

portion of the project service area.* More than one household member is surveyed only when more than one makes this type of trip.

For demonstration projects which serve specific employment or activity centers, e.g., handicapped and elderly service or subscription service, a sample of non-users does not have to be drawn from among households. A sample can be selected from among people at these centers which would include non-users (and users also). If users are surveyed, they should be identified before they answer any questions in order that the questions asked pertain to their use of the project service.

Where a sample of the general population of a region is needed, the sample will always be selected from among the households in the project service area. Again, lists of households can be obtained from utility records, insurance company records, census block statistics, etc.

Regardless of the methods chosen for selecting samples of both users and non-users (and possibly of the general population), every effort should be made to assure that samples selected are unbiased and large enough for the desired statistical confidence. Such an approach involves estimating the percent of persons surveyed who are in the universe (i.e., who make applicable trips in the service area), estimating the response rate, and developing a random selection process that aims at the desired number of samples.**

In developing a random selection process to sample users onboard vehicles, examination of vehicle operating schedules and recent passenger counts, if available, will be necessary to design where and when to select the vehicles on which to sample users. However, the following sources of bias in vehicle operating schedules must be considered when deciding on the utility of a particular schedule for developing a sampling source: (1) unscheduled vehicle runs, most likely to occur during peak hours, and therefore with

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*This comment is also applicable to surveys that are sent to registered automobile owners whose names were obtained from license plate matches.

**See Appendix B for a discussion of sample size determination.

high passenger loads; (2) schedule delays, breakdowns, and accidents, also most likely to occur during peak hours when there are high load factors; (3) the occurrence of exogenous influences on ridership in the interim, such as a strike among people who might have formerly used this mode of transportation, the opening of a new shopping center or school along the route, or unique events such as a concert. These sampling hazards should be kept in mind and some attempt should be made to build corrections into the research design to compensate, such as oversampling on certain routes.

In many situations, developing a random selection process that obtains the desired sample size simply involves selecting every Ith person going past a given point, or every Jth person on a list of users of a given system, or every Kth person on a list of employees at a given location, or writing down the license plate number of every Lth auto going past a given point. To obtain a random sample of the households in the origin portion of a project service area, every Mth household on a list of all of the households in the area could be selected; or the random clustered household sampling method, used on the San Bernardino Freeway Busway project, could be used. This method divides the origin portion of the service area into smaller areas (usually blocks) of approximately equal population and randomly chooses a sample of the resulting clusters in which every household in each cluster is a part of the sample.

The possibility of sampling bias occurring through use of a particular sampling method should not rule out its use. That sampling method may be very appropriate in certain project evaluations. However, where little can be done to minimize the effect of bias, other sampling methods should be considered.

For each survey required for a particular demonstration evaluation, the contractor must carefully describe the universe to which survey research findings will be generalized and identify the most complete enumeration or sampling source available for that universe. Actual selection of a sampling source must be justified in terms of its complete coverage of the affected universe and also in light of the survey objectives.

4. TECHNIQUES FOR SURVEYING THE SAMPLES SELECTED

The final step in executing a survey is determining what techniques are applicable for surveying the samples

that have been selected. There are five basic techniques for surveying these samples:

(1) Self-administered questionnaires handed out by individuals (e.g., survey takers, bus operators, personnel at employment or activity centers) and collected by individuals (not necessarily the same ones as handed out the questionnaires)

(2) Self-administered questionnaires handed out by individuals and returned by mail

(3) Self-administered questionnaires given out by mail and returned by mail

(4) Face-to-face interviews

(5) Telephone interviews.

A summary of the applicable techniques to be used with each possible sampling mothod is shown in Exhibit A-1.

With all of these techniques, the greater the amount of personal contact between user and survey takers, the higher the response rate and the quality and detail of the responses. However, the greater the amount of personal contact, the higher the cost.* In fact, the face-to-face interview initiated at homes, while eliciting the highest response rate, is generally too costly to be considered in the evaluation process. It should only be used in conjunction with the random clustered household sampling method, where the number of personal home interviews to be conducted is small and covers a small area. By significantly decreasing the area in which a given size sample lies, the cost of using personal home interviews is reduced.

Where a self-administered questionnaire is used to survey a sample, the response rate will inevitably be lower than where a face-to-face or telephone interview is used. To improve the response rate it may be desirable to allow for a wave of follow-up procedures, such as phone calls and postcard follow-up.

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*In choosing a survey technique, careful attention should be paid to costs associated with the data processing and analysis of survey findings.

EXHIBIT A-1. SUMMARY OF SURVEY SAMPLING METHODS AND APPLICABLE SURVEY TECHNIQUES

Group Sampled (i.e. users, non-users, or both)	Sampling Method	Survey Technique	Where Surveys Are Distributed	Where Surveys Are to be Completed
Users	Passengers on transit vehicles	A	Onboard transit vehicles	Onboard transit vehicles
		B	Onboard transit vehicles	In homes (or onboard transit vehicles)
		D	Onboard transit vehicles	Onboard transit vehicles
Users	Passengers at transit collection points	A	At transit collection points	Onboard transit vehicles
		B	At transit collection points	In homes (or onboard transit vehicles)
		D	At transit collection points	At transit collection points
Users	Passengers from service registration lists	C	In homes	In homes
		D	In homes	In homes
		E	In homes	In homes
Both	People at specific employment or activity centers	A	At activity centers	At the centers
		B	At activity centers	In homes
		D	At activity centers	At the centers
Non-Users	Autos crossing a screenline: selected by license plate matches	C	In homes	In homes
		E	In homes	In homes
	selected directly from traffic stream	B	At toll booths or the sides of roads	In homes
Both	Households in the origin portion of the project service area selected directly from traffic stream	C	In homes	In homes
		D	In homes	In homes
		E	In homes	In homes

Codes for "Survey Technique":

A - Self-administered questionnaires handed out by individuals and collected by individuals (not necessarily the same ones as handed out the questionnaires)

B - Self-administered questionnaires handed out by individuals and returned by mail

C - Self-administered questionnaires given out by mail and returned by mail

D - Face-to-face interviews

F - Telephone interviews

Generally, the self-administered questionnaire is the most easily conducted and most cost effective survey technique. Self-administered questionnaries initiated onboard or at collection points are most widely applicable. If the questionnaires are short enough to be completed by all users while they are onboard and there are few standees, the users should be instructed to complete the questionnaires while onboard and return them as they leave the vehicle. If the questionnaires are initiated onboard and the number of vehicles on which users are surveyed is not large, consideration should be given to stationing survey takers onboard each vehicle to hand out and collect the questionnaires, give instructions, and answer any questions. If the questionnaires are initiated at collection points and the number of points at which users exit their vehicles is small, consideration should be given to stationing survey takers at the exit points to collect the questionnaires. The additional expense incurred with this degree of personal contact generally pays off, i.e., the response rate is high and the cost per completed survey is low.

Where self-administered questionnaires are too long to be completed by all users while they are onboard or where there are many standees, questionnaires that are to be mailed back should be used. The response rate for a mail back questionnaire will be considerably lower than for a questionnaire completed onboard. This should be kept in mind when developing the sampling techniques.

When questionnaires are sent by mail, a cover letter giving instructions and explaining the purpose of the survey should accompany each questionnarie as should a self addressed, stamped envelope for mailing back the completed questionnaire. It would also be advisable to send out "follow-up" letters a few days after the questionnaires are sent out as a reminder to complete the questionnaires.

There are situations where it is advantageous to conduct personal interviews of users onboard vehicles or at employment or activity centers rather than to have these users complete self-administered questionnaires.* Where the total user population to be surveyed is small, a high response rate may be needed to obtain the desired

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*When surveying users at collection points, there generally is not enough time to question them by personal interview.

statistical confidence. In such a situation, a self-administered questionnaire may not obtain a high enough response rate, while personal interviews of users onboard vehicles would. Where there may be considerable misgivings about answering a self-administered questionnaire, as on a crowded bus or train in some parts of some large cities, personal interviews conducted onboard vehicles may be the only means of obtaining an acceptable response rate. Where the users being surveyed are asked about concepts or behavior that are somewhat complex, a personal interview will be much more effective than a self-administered questionnaire in eliciting usable responses. Handicapped and elderly users may have difficulty writing and it may be difficult for them to respond to a lengthy self-admininstered questionnaire. In such a situation, personal interviews conducted onboard or at activity centers are superior to self- administered questionnaires.

Where samples are selected from service reqistration lists, users can be sent self-administered questionnaires by mail. Where it seems that a very low response rate would be obtained with the mail back questionnaire, or where a high response rate is necessary, the telephone interview would be superior. Moreover, sampling bias would be minimized because all of the users' telephone numbers would be known from the registration lists.*

For surveying non-users, no single technique is widely applicable. Where a sample of auto users crossing a screenline is surveyed, questionnaires could be sent to the auto drivers by mail (from license plate matches) or these same auto drivers could be interviewed by telephone; or auto users selected directly from the traffic stream could be given questionnaires to be returned by mail. On the Shirley Highway project, for example, where autos were selected by license plate matches, auto occupancy was recorded along with license plate number, and mail-back surveys were mailed out according to auto occupancy. Those who drove alone were mailed one form; carpool drivers were mailed a set of

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*It should be noted, however, that it will not be possible to contact all the persons in the telephone survey sample within the survey time frame. Those not contacted may be a nonrandom group, with the result that those who are actually interviewed by telephone may no longer be representative of the universe. Therefore, great care must be exercised when sampling by telephone interview.

different forms: a carpool driver form for themselves, and carpool passenger forms to be given to those who rode with them.

On the Miami project, where autos were also selected by license plate matches, the owners of the observed autos were surveyed by telephone interview. No carpool passengers could be surveyed in this fashion. A particular set of carpool passengers were surveyed directly from the traffic stream. Many carpoolers assembled at a parking lot designated partly for that function. Before each carpool left the lot, each member of the carpool was given a self-administered questionnaire to be mailed back.*

Where a sample of non-users (and users also) is surveyed at specific employment or activity centers, those techniques which are applicable for user surveys initiated onboard or at collection points should be considered. This, in general, means that self-administered questionnaires should be used.

Where a sample of households in the origin portion of the project service area, which includes non-users (and users), is surveyed, no single survey technique is widely applicable. Questionnaires could be sent to those households by mail to be returned by mail, telephone home interviews could be conducted, or personal home interviews could be conducted where the sample is selected using the random clustered sampling method.

To further assist in the selection of appropriate survey techniques, a summary of the recent survey experience of three of the contractors performing evaluations of SMD projects is presented in Exhibit A-2. The information presented can provide a basis for planning of similar types of surveys during the various SMD projects.

The data in Exhibit A-2 is classified by three primary survey types, namely, onboard vehicle, household, and telephone. For each set of information, the specific contractor is identified so that organizations desiring more detailed information can make appropriate contacts. In addition, the following items are included:

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*Some carpool drivers might have been surveyed twice if their license plates had been recorded.

EXHIBIT A-2. RECENT SURVEY EXPERIENCE OF CONTRACTORS

The following should be noted with respect to the consultant firms:

1. Systan represents Systan, Inc., located in Los Altos, California.
2. ECI represents ECI Systems, Inc., located in Cambridge, Massachusetts.
3. Crain represents Bigelow-Crain Associates located in Menlo Park, California.

	ON-BOARD VEHICLES		HOUSEHOLDS
	ECI	Crain	Systan
Locations	Rochester (Dial-A-Ride)	1. Cleveland, Ohio 2. San Bernardino Freeway	San Francisco Bay Area
Questionnaire Types	Self-administered; distributed and collected on-board	In both places, face-to-face interview; distributed and collected.	Hand delivered and collected; self-administered
Duration/Length	One side - 8-1/2" x 14"; 8-1/4" x 11"; 15 minute average travel times	2-3 minutes (face-to-face)	20-25 minutes
Survey Costs[1]	--	$.85/questionnaire	$2/return
Response Rates	97%; 98%	93% - peak 85% - off-peak	79% - individual responses 73% - household responses (% of households in which one or more survey was completed and returned)
Comments	Used temporary help and local market research firm; latter cheaper and more reliable.	Cooperative ridership	Long questionnaire; 141 items, with 2-7 alternatives and some open-ended

EXHIBIT A-2 (CONT)

	HOUSEHOLDS	TELEPHONES	
	Crain	Systan	ECI
Locations	1. San Bernardino Freeway 2. Menlo Park, California	Amherst	Rochester
Questionnaire Types	In San Bernardino, face-to-face, doorstep type; hand-delivered & collected; in Menlo Park, self-administered; mail back.	N/A	N/A
Duration/Length	5-7 minutes in San Bernardino; in depth, longer in Menlo Park.	5 minutes	8-10 minutes
Survey Costs	$1.15/interview[1] $6.50/interview[2] (search) $2.60/questionnaire	$1/call	--
Response Rates	Averages 85% of contacts: 50% on mail back.	97% response rate to first wave of calls decreased steadily to a 56% response rate to the fourth wave of calls	Almost 100% (.6% refusal rate)
Comments	In general, search type studies more costly, time consuming and lower response rates.	Four waves of calls made to same initial sampled group; many people in group had moved out or had their phone disconnected during the time between the first and the last wave of calls	Sampled subscriber lists; lack of telephone numbers in list reduced sample frame by 20% (from 210 to 164)

1) Assumes no search for a specific group (e.g., transit system users), unless otherwise stated.

2) This cost is based on a household survey of the San Bernardino Freeway Corridor which searched out commuters to the downtown area. Of the 6672 houses contacted (8008 were approached) only 14% had a commuter(s) whom we were interested in interviewing and only 8.6% (576) of the contacts resulted in valid, usable responses.

(1) Locations - an identification of the areas in which the specific surveys were conducted.

(2) Questionnaire types - an indication of the specific methodology employed for the survey.

(3) Duration/Length - an indication of the time required to conduct the survey, or related information.

(4) Survey costs - experience information relative to various costs including additional detail, as appropriate.

(5) Response rates - an indication of experienced response rates based upon total sample information.

(6) Comments - general comments emanating from these specific surveys. In some instances, these comments suggest potential areas of concern.

In addition to the information highlighted in Exhibit A-2, the following comments are in order relative to the overall experience of the three contractors in conducting surveys:

(1) Response rates greater than 90% occur where face-to-face contacts are made. In addition, even in the case where searches are required, response rates tend to be fairly high in face-to-face contact. Mail surveys in general tend to produce response rates on the order of 50%.

(2) Individual survey costs can vary dramatically depending upon the type of survey, the sample size, and the response rates. Indications in Exhibit A-2 identify rates ranging from 85¢ per questionnaire to as much as $6.50 per interview.

(3) There are two primary approaches with respect to staffing survey operations. The first involves untrained local personnel, usually obtained through university contacts, but under the complete training and supervision of an individual from the consulting firm who is experienced in such surveys. The other alternative is to contract directly with local organizations, either personnel or market research firms.

(4) In using a universe which consists of a listing of individuals (e.g., a subscription listing) it is critical to determine how up-to-date the listing is as well as how easily the sample can be selected.

It is important to recognize that the data contained in Exhibit A-2 is for planning purposes only and should not be construed as absolute, particularly in the response rates that were experienced.

It is anticipated that TSC will set up a "Survey Notebook" in which will be kept a record of the survey experience of the contractors during their performance of SMD evaluations. In order for TSC to maintain this notebook, it is hoped that for each survey conducted for SMD projects, the contractor will supply TSC with a copy of the survey form, information on universe size, sample size, cost, and response rate, and reasons associated with non-response.

5. SURVEY DESIGN PRINCIPLES

It is apparent that because different surveys are directed at different survey universes using different sampling sources and different techniques, surveys will vary in content and length. Nonetheless, all surveys should have the same basic organization, sequence, and wording of standardized questions. This section presents basic principles on survey organization, length, question sequence and wording, and standardized questions that should be followed in designing the survey instrument.

a. Organization

There should be four elements in all surveys, whether user or non-user. They are in order of their appearance in a survey:

(1) Introduction - This is a brief statement of the survey's purpose and potential utility and guarantees the respondent's anonymity. It will be verbally delivered if an interview technique is selected, or will be printed at the beginning of a self-administered questionnaire.

(2) Behavioral and Attitudinal Measures - These refer to the set of questions specifically measuring the survey's objectives, such as modal shift, satisfaction with level of service, etc.

(3) Social and Demographic Measures - These are measures of the respondent's characteristics which are important in interpreting responses to behavioral and attitudinal measures. Transition to this section of a survey needs to be prefaced by either a verbal or written explanation, as appropriate, such as "Now we need to know a little about you...."

(4) Closing Statement - This is a brief expression of thanks to the respondent for participating, with some indication of the importance of the eventual utilization of his responses, and a request from the respondent for any additional comments or observations.

b. Length

The overall length of the survey depends on the particular objectives of the survey and the survey techniques used (see Section 4 of this Appendix). In general, surveys which are to be completed onboard transit vehicles and at employment and activity centers should be shorter than those surveys completed at home, since they are being administered to respondents in a less comfortable and relaxed environment.

Self-administered questionnaires which are handed out should be limited in length to one side of a sheet of paper or a large postcard. Surveys which are to be completed onboard transit vehicles and at employment and activity centers (whether in interview or self-administered format) should be shorter than surveys which can be filled out at the respondent's convenience and returned by mail. Moreover, they should be short enough so as not to delay the respondent in his trip or current activity.

The length of surveys which are completed in the home varies depending on the method of administration. Telephone surveys should be fairly short, since it is difficult to retain the respondent's attention for any longer period given the impersonal nature of the contact. Self-administered mail-back questionnaires given out by mail can be longer than self-administered mail-back questionnaires

handed out because there is more opportunity to enlist the respondent's cooperation. However, mail-back questionnaires given out by mail should not be as extensive as personal interviews conducted in the home, since again the personal contact is lacking which might encourage a longer attention/cooperation span on the part of the respondent.

c. Question Sequence and Wording

There are several general principles describing question sequence and wording that apply to all questions. First, questions should be arranged logically to lead the respondent into the frame of reference of the issue under study.* It is recommended, following the introductory material, to begin the questionnaire or interview schedule with behavioral or attitudinal measures of responses to transportation alternatives because these relate most closely to the announced purpose of the data collection effort. Social and demographic data should be collected near the end of the survey instrument, reserving any questions about income as near to the end of the survey as possible.**

Questions should be as short as possible and in clear, concrete language. Visual format is also important. In self-administered questionnaires, it enhances the respondent's likelihood of completing the form, and in

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*See pages 26 ff in Federal Highway Administration with Urban Mass Transportation Administration, Urban Mass Transportation Travel Surveys, for an extended discussion of the basic considerations in designing surveys. Two very practical descriptions of interviewing and coding guidelines helpful in developing format are contained in: Survey Research Center, Interviewer's Manual, Institute for Social Research, University of Michigan, May 1969 and Survey Research Center, A Manual for Coders, Institute for Social Research, University of Michigan.

**Measures of income are the most difficult to obtain accurately and arouse the greatest resistance in the respondent. Sometimes a respondent is asked to point to an amount on a card or circle an approximate amount to lessen the resistance. However, these items arouse such resistance that they must be at the end of the data collection instrument so the hostility produced will not destroy the rest of the data collection.

interview format surveys, it makes the interviewer's task faster and easier. Questions should be laid out in a fashion that ensures ease of coding and keypunching responses and appears attractive at the same time. Fill-in questions should be avoided where possible, because they are difficult to code. Where they are used, responses should be anticipated and precoded to reduce costs and enhance consistency. Coding blocks can be left at one side of the survey form and the field editor can check that information is transferred. This procedure makes the survey also function as a code sheet.

The survey should be checked to ensure that it is as parsimonious and logical as possible. There are several ways to do this. First, every question ought to be evaluated to ensure that it contains a measure related to one of the specific project objectives.* Second, advance planning of the data analysis, through the construction of dummy tables, will ensure that every variable measured contributes to the eventual data analysis. Finally, pretesting of the survey instrument will identify any questions which, because they are confusing to the respondent or of limited use in the evaluation, should be changed or omitted. Pretesting has even more far-reaching benefits. It will uncover any procedural problems which may arise during the survey process and reveal any problems which are particularly characteristic of urban areas, such as a sizable number of functional illiterates or foreign speaking respondents who cannot complete a self-administered questionnaire or a systematic refusal to participate by some sectors of the population. The pretest of the survey form must be conducted with respondents as identical to the proposed survey respondents as possible without contaminating the sampling source.

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*There are several exceptions to this guideline. One is the deliberate use of one or two meaningless questions in order to lead the respondent into a particular frame of reference. This is frequently necessary when seeking information on embarrassing, unusual, highly specific or complicated issues. This technique will increase the validity of the data subsequently collected. A second exception is measuring respondent's opinions of service features that have not changed as part of a set of questions about respondents' reactions to improved service features. This combination of questions will measure if a "halo effect" exists in terms of respondents' overall positive evaluation of the mode when only several aspects have been changed.

Finally, all survey questions should be checked against the provisions of the Privacy Act of 1974 to verify that none of the questions violates any person's right to privacy as spelled out in the Act. It is recommended that the contractors familiarize themselves with the provisions of the Act.

d. Standardized Questions

It will be useful to ensure that the data collected in different evaluation projects is consistent in format. Fostering consistency means that an economical amount of data will yield a maximum amount of information. Secondly, consistency facilitates comparisons between projects, generating a more universally applicable understanding of the responses to transit innovations. Finally, and most importantly, developing consistent data collection categories based on the U.S. Census will mean that results of any survey can be corrected for sampling error and potentially extrapolated to any other area. This section discusses standardized formats for measuring behavioral, attitudinal, and social/demographic characteristics.

(1) Behavioral Measures

Selecting questions to measure travel behavior is very much influenced by the objectives of a particular survey. Some general suggestions regarding ways to collect and code such information to increase consistency among surveys will be described.

The following measures of travel behavior are most likely to be asked in almost every survey: transit vehicle boarding and alighting points (user surveys only), trip origin and destination (all described in terms of addresses), trip purpose, and trip start and end times. Additional frequently collected data for surveys includes access mode to transit vehicle, when present mode was first used for this particular trip, former mode used for this particular trip (with some attempt to control for exogenous influences, such as a residential move)*, reason for switching mode, fare (user surveys only), tolls and parking cost (non-user surveys only), frequency of use, access time

---

*The 1974 Shirley Highway bus user survey (see Exhibit A-3) attempts this.

at origin and destination (user surveys only), availability of mass transit alternatives, back-up mode, and number of transfers required (user surveys only).

Exhibits A-3 through A-6 are examples of user surveys; Exhibits A-7 through A-9 are examples of non-user surveys. These exhibits, together with the preceeding discussion, indicate the possible range of information which can be collected on travel behavior. Clearly, the determination of which particular items to include in a survey depends on the survey objective, desired survey length, and circumstances under which the survey is conducted. Furthermore, the specific wording of the questions relating to travel behavior depends on the method of administering the survey and the overall tone of the survey and sequence of questions.

Exhibits A-10 through A-16 present recommended question formats and response categories for the measures of travel behavior which are likely to be included in most user and non-user surveys. These recommendations are based on a review and evaluation of questions asked in past surveys (including Census Journey-to-Work) and are directed to the five basic types of surveys (See Exhibit A-1). In designing a survey for a particular demonstration project, the contractor should follow these guidelines to the extent consistent with the scope and objectives of the survey. Any significant deviations from the recommendations, particularly modifications of suggested response categories, should be explained to TSC in a memorandum accompanying the draft survey instrument.

(2) Attitudinal Measures

Attitudinal items will be used in many surveys to measure the respondent's evaluation of the transit service provided, specifically in terms of such service characteristics as reliability, convenience, attractiveness, and safety of alternative modes. Attitudinal questions may also be used to determine what factors have influenced a modal change. Construction of such items requires careful design and will lengthen the survey's administration time. Occasionally, attitudinal questions may be used to obtain a profile of the community in which the transit service is being provided. An entire survey would then be designed explicitly for the purpose of determining the opinions of the general population in the project service area to such things as the role of government, environmental issues, adequacy of transportation facilities, and desirability of travel by alternate mode.

EXHIBIT A-3

SHIRLEY HIGHWAY CORRIDOR SELF-ADMINISTERED BUS SURVEY

NBS-760
(9-73)

OMB No. 41-R2752
Approval Expires 12-31-76
U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

Shirley Highway Corridor Bus Commuter Survey

This survey is sponsored by the U.S. Department of Commerce

THE FOLLOWING QUESTIONS CONCERN THE TRIP YOU ARE MAKING THIS MORNING

Please Answer All Questions and Mail — No Stamp Required

1. At what corner (or park-and-ride lot) did you board this bus?
   (specify nearest street intersection) [8 10]
2. How did you get from the place where this trip began to the place where you boarded this bus? [11]
   ☐ walked ☐ was driven by another person
   ☐ drove car and parked
   ☐ other (specify) _____
3. Where did this trip begin? (Your home address if this trip started at home)
   Street Address 12 — 41
   City 42 — State 69 — Zip Code 70 — 74
4. This address was ☐ home ☐ other (specify) _____ [75]
5. Time you began this trip _____ A.M. (left above address) [76 79]
6. What was the final destination of this trip? (*Physical address* of your work place, if work trip)
   Street address or building name 12 — 41
   City 42 — State 69 — Zip Code 70 — 74
7. This address was ☐ work ☐ other (specify) _____ [75]
8. Time this trip ended ____ A.M. (arrived at above address) [76 79]
9. When you made this trip how much time did you spend driving (or being driven) from the place where this trip began to the place where you left your auto?
   ☐ not applicable, or _____ minutes [8 10]
10. When you made this trip how much time did you spend walking to *and from* bus stops and waiting for buses? _____ minutes [11 12]
11. When you made this trip how many times did you change (transfer) buses? [13]
    ☐ none, or _____ transfers
12. When did you begin to regularly use this bus to commute from home to work? ☐ not applicable, or ____ month ____ year [14 17]

PLEASE CONTINUE TO QUESTION 13 ABOVE

13. How often do you use *each* of the following means to travel from home to work? [18 20]
    a) This bus ____ (0,1,2,etc.) day(s) per week
    b) Driving alone ____ day(s) per week
    c) A carpool ____ day(s) per week
14. Does this bus arrive at your *boarding* bus stop later than the scheduled time? [21]
    ☐ never ☐ seldom ☐ usually ☐ always
15. Does this bus arrive at your *destination* bus stop later than the scheduled time? [22]
    ☐ never ☐ seldom ☐ usually ☐ always
16. On an average day when you board this bus do you find a seat? [23]
    ☐ never ☐ seldom ☐ usually ☐ always
17. If you could not commute from home to work by means of this bus how would you usually make the trip? [24]
    ☐ would be unable to make this trip
    ☐ join or form a carpool ☐ use another bus
    ☐ drive alone ☐ other (specify) _____
16. Before you began using this bus how did you usually commute from home to work? [25 26]
    ☐ did not make this trip (from your present home to your present work place); how did you commute prior to changing your place of residence or work?
    ☐ auto ☐ bus ☐ other
    ☐ drove alone
    ☐ was an alternate driver in a carpool with ____ other person(s)
    ☐ drove in a carpool with ____ other person(s) (always or nearly always drove)
    ☐ was a passenger in a carpool with ____ other person(s) (never or almost never drove)
    ☐ used another bus (specify route) _____
    ☐ other (specify) _____
19. If prior to riding this bus you commuted regularly by automobile (as either a driver or passenger), why did you switch to bus? [27 28]
20. If prior to riding this bus you commuted regularly by auto, what was the vehicle parking cost? (*Don't* divide by the number of persons sharing the parking cost) [29 31]
    ☐ not applicable, or $ _____ per day.
21. During the past two years has this bus service enabled you to: [32 33]
    a) dispose of a car which you owned? ☐ yes ☐ no
    b) avoid buying a car? ☐ yes ☐ no
22. Did this bus service influence the choice of your present address? [34]
    ☐ yes, definitely ☐ slightly ☐ not at all

23. What are your regular working hours? ☐ no regular working hours, or _____ A.M. to _____ P.M. [35 38] [39 42]
24. When was the last time you changed your place of residence? ☐ not within the last 5 years, or _____ month _____ year [43 46] [47 50]
25. When was the last time you changed your *physical work location?* ☐ not within the last 5 years, or _____ month _____ year
26. Is an auto available for you to REGULARLY drive alone from home to work? [51]
    ☐ no ☐ yes, but with considerable inconvenience to others ☐ yes, and without inconvenience to others ☐ don't drive
27. How many automobiles are owned or operated by members of your household? ☐ none, or _____ auto(s). [52]
28. Which of the following attitudes best expresses your opinion about using bus as a way of commuting from home to work? [53]
    ☐ I am generally satisfied with using bus as a *long range* solution to my commuting problems.
    ☐ I am generally satisfied with using bus as a *short term* solution to my commuting problems until I can use metro subway service.
    ☐ I am generally dissatisfied with using bus; why _____
    ☐ Other (specify) _____
29. Please indicate your: [54 55]
    Sex: ☐ male ☐ female
    Age: ☐ under 21 ☐ 21-39 ☐ 40-65 ☐ over 65
30. What is the combined annual income of all members of your household? [56]
    ☐ $0-5,000 ☐ $5,001-15,000 ☐ $15,001-30,000 ☐ above $30,000
31. Any comments? _____ [57 58]

THANK YOU — PLEASE SEAL AND MAIL

EXHIBIT A-4

MINNEAPOLIS SELF-ADMINISTERED AUTO USER SURVEY

Survey is sponsored by U.S. Dept. of Transportation
Please give us a few minutes and we will try to give you a better Transportation system.

R. L. Eggerud
Commissioner of Highways

Doug Kelm
Chairman, Metropolitan Transit Commission

OMB 04-R5637

1. The place I came from was _____ Home? ☐ YES ☐ NO
(Address or Street Intersection)

2. The place I was headed for was _____ Work? ☐ YES ☐ NO
(Address, Building or Street Intersection)

3. I began this trip at about _____ A.M.; and arrived at my destination at about _____ A.M.

4. What are your regular working hours? _____ A.M. to _____ ☐ A.M. ☐ P.M.

5. When I made this trip I was:

☐ the driver (with _____ passengers)
☐ alternate driver of a car pool
☐ regular passenger and pay $_____ per _____. ☐ FREE

6. Do you normally use this car during the business day? ☐ YES ☐ NO

7. What is the vehicle parking cost? _____ per _____ (day, week, month, year) ☐ FREE

8. If you formerly traveled by bus, what is the major reason you switched to the auto?

☐ cheaper ☐ less travel time ☐ other _____ (Specify)
☐ safer ☐ more dependable
☐ did not make trip by bus

9. Could you have used a local bus to make this trip?

☐ yes, but chose not to because _____
☐ no, because _____
☐ don't know

10. Could you have used the I-35W Express bus service for this trip?

☐ yes, but chose not to because _____
☐ no, because _____
☐ don't know

11. If one transit improvement could be made, which of the following would induce you to ride the bus? (Check only one)

☐ Lower fare ☐ More comfortable vehicle ☐ More extensive service (less walking)
☐ More frequent service ☐ No need to transfer ☐ Other _____ (Specify)
☐ Less traveling time

12. How would you rate your general attitude toward traveling to work by bus?

☐ Very positive ☐ Positive ☐ Negative ☐ Very negative

Now, just a few questions for statistical purposes:

13. How long have you lived at your present address? _____ Years _____ Months

14. How many autos are owned or operated by members of your household?

☐ None ☐ One ☐ Two ☐ More than two autos

15. Are you: ☐ Male ☐ Female What is your age? _____

16. My combined annual family income is:

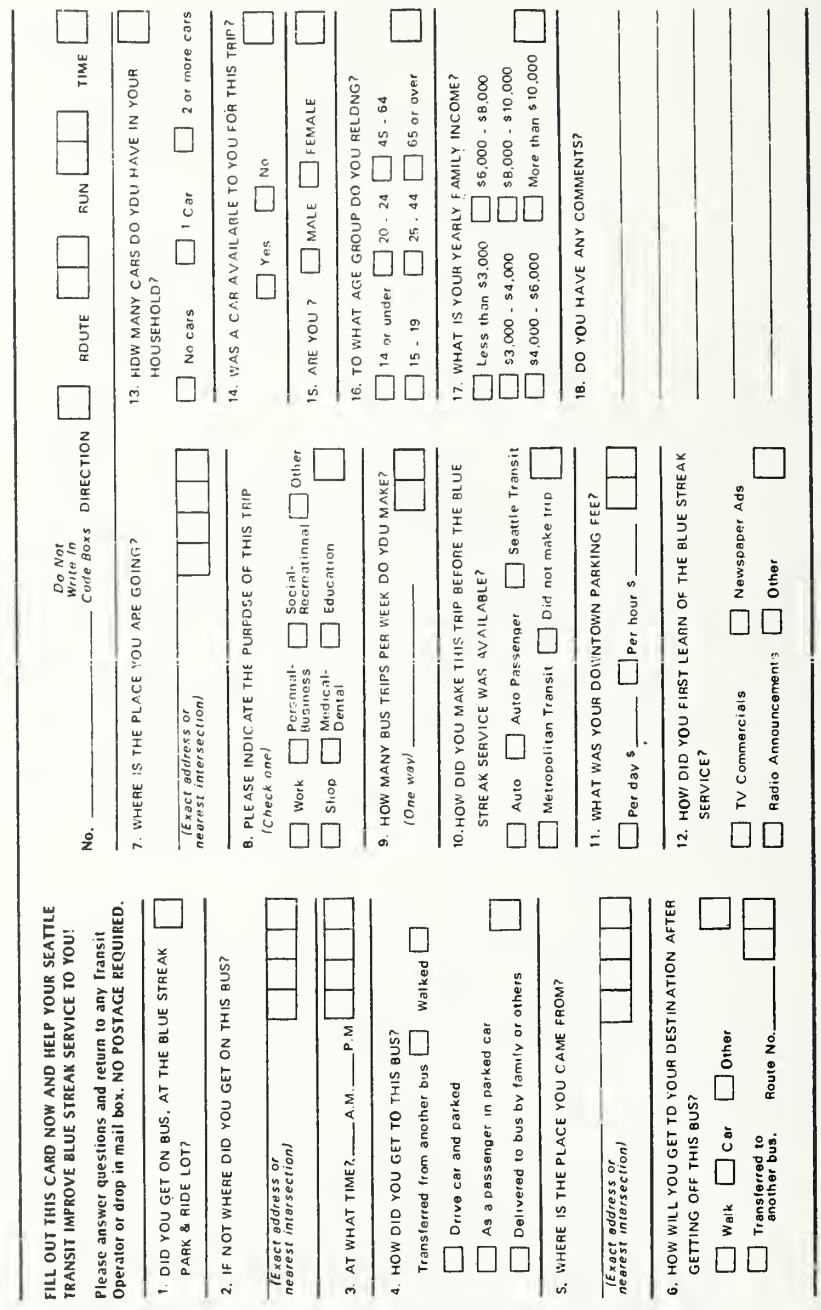
☐ Under $3,000 ☐ $5,000-$7,999 ☐ $10,000-$11,999 ☐ $15,000-$19,999 ☐ $25,000-$29,999
☐ $3,000-$4,999 ☐ $8,000-$9,999 ☐ $12,000-$14,999 ☐ $20,000-$24,999 ☐ $30,000 or more

THANK YOU ····· Please seal and mail

32987

EXHIBIT A-5

SEATTLE BLUE STREAK SELF-ADMINISTERED BUS SURVEY



FILL OUT THIS CARD NOW AND HELP YOUR SEATTLE TRANSIT IMPROVE BLUE STREAK SERVICE TO YOU!

Please answer questions and return to any transit Operator or drop in mail box. NO POSTAGE REQUIRED.

No. _____ *Do Not Write in Code Boxes* ROUTE ☐☐ RUN ☐☐ DIRECTION ☐ TIME ☐

1. DID YOU GET ON BUS, AT THE BLUE STREAK PARK & RIDE LOT? ☐

2. IF NOT WHERE DID YOU GET ON THIS BUS?
(Exact address or nearest intersection) ☐☐☐☐

3. AT WHAT TIME? ___ A.M. ___ P.M. ☐☐☐☐

4. HOW DID YOU GET TO THIS BUS?
Transferred from another bus ☐ Walked ☐
☐ Drive car and parked
☐ As a passenger in parked car
☐ Delivered to bus by family or others ☐

5. WHERE IS THE PLACE YOU CAME FROM?
(Exact address or nearest intersection) ☐☐☐☐

6. HOW WILL YOU GET TO YOUR DESTINATION AFTER GETTING OFF THIS BUS?
☐ Walk ☐ Car ☐ Other ☐
☐ Transferred to another bus. Route No. ☐☐

7. WHERE IS THE PLACE YOU ARE GOING?
(Exact address or nearest intersection) ☐☐☐☐

8. PLEASE INDICATE THE PURPOSE OF THIS TRIP *(Check one)*
☐ Work ☐ Personal-Business ☐ Social-Recreational ☐ Other
☐ Shop ☐ Medical-Dental ☐ Education ☐

9. HOW MANY BUS TRIPS PER WEEK DO YOU MAKE?
(One way) _____ ☐☐

10. HOW DID YOU MAKE THIS TRIP BEFORE THE BLUE STREAK SERVICE WAS AVAILABLE?
☐ Auto ☐ Auto Passenger ☐ Seattle Transit
☐ Metropolitan Transit ☐ Did not make trip ☐

11. WHAT WAS YOUR DOWNTOWN PARKING FEE?
☐ Per day $ ____ ☐ Per hour $ ____ ☐☐

12. HOW DID YOU FIRST LEARN OF THE BLUE STREAK SERVICE?
☐ TV Commercials ☐ Newspaper Ads
☐ Radio Announcements ☐ Other ☐

13. HOW MANY CARS DO YOU HAVE IN YOUR HOUSEHOLD?
☐ No cars ☐ 1 Car ☐ 2 or more cars ☐

14. WAS A CAR AVAILABLE TO YOU FOR THIS TRIP?
☐ Yes ☐ No ☐

15. ARE YOU ? ☐ MALE ☐ FEMALE ☐

16. TO WHAT AGE GROUP DO YOU BELONG?
☐ 14 or under ☐ 20 - 24 ☐ 45 - 64
☐ 15 - 19 ☐ 25 - 44 ☐ 65 or over ☐

17. WHAT IS YOUR YEARLY FAMILY INCOME?
☐ Less than $3,000 ☐ $6,000 - $8,000
☐ $3,000 - $4,000 ☐ $8,000 - $10,000
☐ $4,000 - $6,000 ☐ More than $10,000 ☐

18. DO YOU HAVE ANY COMMENTS?
_____
_____
_____
_____

SOURCE: FHWA and UMTA, Urban Mass Transportation Travel Surveys, Exhibit 4-19.

EXHIBIT A-6

WASHINGTON, D.C., SELF-ADMINISTERED POST CARD

BUS SURVEY

TO BUS RIDERS: Please help to plan your future bus and subway systems by telling us ABOUT THE TRIP YOU ARE NOW TAKING. Drop completed card in box at door or hand to driver. If you don't have a pencil now, the card can be mailed free.

1. I got on this bus at _____ (NEAREST STREET CORNER) (CITY OR COMMUNITY)
2. I have come from: ☐home ☐work ☐shopping ☐school ☐other
3. This place I have come from is at _____ (ADDRESS OR NEAREST CORNER) _____ (CITY OR COMMUNITY)
4. I am getting off this bus at _____ (NEAREST STREET CORNER) (CITY OR COMMUNITY)
5. I am now headed for: ☐home ☐work ☐shopping ☐school ☐other
6. This place I am headed for is at _____ (ADDRESS OR NEAREST CORNER) _____ (CITY OR COMMUNITY)

№ 465003

PLEASE FILL OUT BOTH SIDES

BUDGET BUREAU NO. 117-5601

UNITED STATES GOVERNMENT NATIONAL CAPITAL TRANSPORTATION AGENCY

PLEASE FILL OUT BOTH SIDES

7. How did you get to this bus:
   ☐Walked ☐Drove and Parked ☐Car Passenger
   ☐Bus ☐Train ☐Taxi or Other
8. How will you get from this bus to where you are headed:
   ☐Walk ☐Bus _____ (Route Number of bus transferred to)
   ☐Car ☐Taxi or Other
9. Check the number of cars in your household:
   ☐None ☐1 Car ☐2 Cars ☐More than two

IF YOU TRANSFER ON THIS TRIP PLEASE DO NOT TAKE ANOTHER CARD

THANK YOU

UNITED STATES GOVERNMENT
NATIONAL CAPITAL TRANSPORTATION AGENCY
WASHINGTON, D.C. 20432
OFFICIAL BUSINESS

POSTAGE AND FEES PAID N.C.T.A.

NCTA TRANSIT SURVEY
P.O. BOX 9366
WASHINGTON, D.C.
20005

SOURCE: FHWA and UMTA, Urban Mass Transportation Travel Surveys, Exhibit 4-3.

EXHIBIT A-7

SHIRLEY HIGHWAY CORRIDOR SELF-ADMINISTERED CARPOOL DRIVER SURVEY

NBS-793
(8-74)

OMB No. 41-874087
Approval Expires 12-31-74
U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

Shirley Highway Corridor Carpooler Survey

This survey is sponsored by the U.S. Department of Commerce

1 Were you the *driver* in a carpool (that is, an automobile carrying 2 or more persons, including the driver) on the morning of _____ between 6:30 A.M. and 8:00 A.M.?
☐ yes, please answer the following questions and mail survey form — No Stamp Required
☐ no, please return survey form without answering questions

2 LISTED BELOW ARE SEVERAL FACTORS WHICH MIGHT FIGURE EITHER POSITIVELY OR NEGATIVELY IN A PERSON'S DECISION TO FORM OR JOIN A CARPOOL. HOW IMPORTANT WAS EACH OF THESE FACTORS TO YOU WHEN YOU ***FIRST DECIDED*** TO USE THE CARPOOL IN WHICH YOU WERE RIDING ON THE MORNING CITED ABOVE?

BESIDE *EACH* OF THE FACTORS BELOW, PLACE ONE OF THE FOLLOWING "IMPORTANCE" NUMBERS:

3 = Very Important
2 = Moderately Important
1 = Unimportant or Didn't Consider It
0 = Not Applicable

___ Comfort of the vehicle(s) used by the carpool (e.g., leg room, air conditioning, etc.)
___ Reduction in overall commuting costs
___ Loss of personal privacy
___ Special parking privileges provided by employer for carpools
___ Characteristics of the other member(s) of the carpool (e.g., personality, punctuality, sex, whether person is a smoker or objects to smoking, etc.)
___ Availability of Shirley Highway express lanes for carpool use
___ Loss of flexibility in working hours
___ Availability of carpool locator services
___ Additional trip time resulting from passenger pick up and discharge
___ Reduced use of an auto or making the purchase of an auto unnecessary
___ Additional risk to personal safety
___ Concern for energy and air pollution problems
___ Convenient work location(s) of the other member(s) of the carpool
___ Reduction in the use of gasoline
___ Additional auto insurance required
___ Reduced stress and frustration in commuting
___ Availability of good bus service as "back-up" transportation
___ Other factors (specify) _____

3 What intervening stop(s) did you make between the place where this trip began and your final destination, other than to pick up and discharge carpool passengers?
☐ none ☐ restaurant
☐ babysitter ☐ other(s) (specify) _____

PLEASE CONTINUE TO QUESTION 4 ABOVE

4 Where did this trip begin? (Your home address if this trip started at home)
Street Address _____
City _____ State _____ Zip Code _____

5 This address was ☐ home ☐ other (specify) _____

6. Time you began this trip _____ A.M. (left above address)

7 What was the final destination of this trip? *(Physical address* of your work place, if work trip)
Street address or building name _____
City _____ State _____ Zip Code _____

8 This address was ☐ work ☐ other (specify) _____

9 Time this trip ended _____ A.M. (arrived at above address)

10 When you made this trip how many persons were in the auto? (EXCLUDING YOURSELF) _____ person(s)

11. When you made this trip where did you pick up carpool passengers? (EXCLUDING YOURSELF)
___persons were picked up at or near *their* residences
___persons were picked up at other location(s)

12. When you made this trip, how many persons in the auto were discharged before you arrived at the place where you parked your auto? ☐ none, or _____ person(s)

13 When you made this trip how long did it take you to travel from your home (or place where trip began) to the *place where the last passenger was picked up?*
☐ not applicable, or _____ minutes

14. When you made this trip, where did you park your auto?
☐ on the street ☐ in a space provided or subsidized by your employer
☐ in a commercial lot/garage
☐ other (specify) _____

15 What is the vehicle parking cost? *(Don't* divide by the number of persons sharing the parking cost) ☐ not applicable, or $ _____ per day

16 Could you have used a bus to make this trip? ☐ yes ☐ no ☐ don't know

17 The following questions (a-o) refer to the carpool in which you were riding on the morning cited above. If you are not currently an active and regular member of *this* carpool please check here and return survey form without answering the remaining questions. ☐

a) When did you begin to regularly use *this* carpool to commute from home to work? _____ month _____ year

b) How many persons usually commute from home to work in *this* carpool? (EXCLUDING YOURSELF) _____ person(s)

c) How often are you the driver of *this* carpool?
☐ never or almost never drive
☐ alternately drive
☐ always or nearly always drive

d) During the last year has the membership of *this* carpool increased for any reason?
☐ no
☐ yes, (EXCLUDING YOURSELF) increased from _____ person(s) to _____ person(s)

e) What motivated the increase in membership of *this* carpool?
☐ not applicable
☐ the opening of Shirley Highway express lanes to carpools
☐ an employer policy providing parking, especially to carpools with some minimum membership
☐ carpool locator services
☐ the gasoline crisis
☐ other (specify) _____

f) How often do you use *each* of the following means to travel from home to work
i. *This* carpool _____ (0,1,2,etc.) day(s) per week
ii. Driving alone _____ day(s) per week
iii. Bus _____ day(s) per week

g) How many regular users of *this* carpool (EXCLUDING YOURSELF) are
i. members of your household? ☐ none, or _____ person(s)
ii. employed at your place of work? ☐ none, or _____ person(s)

h) Does the number of people using *this* carpool vary from day to day?
☐ stays the same from day to day (except for sick days and vacation)
☐ varies somewhat from day to day
☐ varies substantially from day to day

i) How do the participants in *this* carpool share the vehicle operating and parking costs? (e.g., share driving, pay driver fixed amount, etc.) _____

j) How often does *this* carpool make use of the Shirley Highway lanes reserved to buses and carpools of 4 or more persons?
☐ not applicable, or _____ day(s) per week. Where do you enter the reserved lanes in the morning? _____

k) Did a carpool matching service assist you in joining or forming *this carpool*? ☐ yes ☐ no

l) If you could not commute from home to work by means of *this* carpool how would you usually make the trip?
☐ would be unable to make this trip
☐ join or form another carpool ☐ use bus
☐ drive alone ☐ other (specify) _____

m) Before you joined *this* carpool how did you usually commute from home to work?
☐ did not make this trip (from your present home to your present work place); how did you commute prior to changing your place of residence or work? ☐ auto ☐ bus ☐ other
☐ drove alone, which roadway was used?
☐ Columbia Pike ☐ Shirley Highway ☐ Route 1
☐ Arlington Blvd. ☐ George Washington Parkway
☐ Other (specify) _____
☐ was an alternate driver in a carpool with _____ other person(s)
☐ drove in a carpool with _____ other person(s) (always or nearly always drove)
☐ was a passenger in a carpool with _____ other person(s) (never or almost never drove)
☐ used bus (specify route) _____
☐ other (specify) _____

n) Before you joined *this* carpool how long did it take you to commute from home to work? _____ minutes

o) Before you joined *this* carpool where did you park your auto?
☐ did not drive
☐ in a space provided or subsidized by your employer
☐ on the street
☐ in a commercial lot/garage
☐ other (specify) _____

PLEASE CONTINUE TO PART j OF QUESTION 17 ABOVE

18. Would *your* employer provide you with parking if you were not participating in a carpool? ☐ yes ☐ no ☐ don't know

18. What are your regular working hours? ☐ no regular working hours, or _____ A.M. to _____ P.M.

20. When was the last time you changed your place of residence? ☐ not within the last 5 years, or _____ month _____ year

21. When was the last time you changed your *physical work location?* ☐ not within the last 5 years, or _____ month _____ year

22. Is an auto available for you to REGULARLY drive alone from home to work?
☐ no ☐ yes, but with considerable inconvenience to others ☐ yes, and without inconvenience to others

23. How many automobiles are owned or operated by members of your household? ☐ none, or _____ auto(s)

24. Which of the following attitudes best expresses your opinion about carpooling as a way of commuting from home to work?
☐ I am generally satisfied with carpooling as a *long range* solution to my commuting problems.
☐ I am generally satisfied with carpooling as a *short term* solution to my commuting problems until improvements are made in mass transit.
☐ I am generally dissatisfied with carpooling, why _____
☐ Other (specify) _____

25. Please indicate your: *Sex:* ☐ Male ☐ Female *Age* ☐ under 21 ☐ 21-39 ☐ 40-65 ☐ over 65

26. What is the combined annual income of all members of your household? ☐ $0-5,000 ☐ $5,001-15,000 ☐ $15,001-30,000 ☐ above $30,000

27. Any comments? _____

THANK YOU — PLEASE SEAL AND MAIL

EXHIBIT A-8

SHIRLEY HIGHWAY CORRIDOR SELF-ADMINISTERED SOLO DRIVER SURVEY

NBS-796
(8-74)

OMB No. 041-S7407B
Approval Expires 12-31-74
U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

Shirley Highway Corridor Single Occupant Auto User Survey

This survey is sponsored by the U.S. Department of Commerce

1. Did you make a trip by *driving alone* in an automobile on the morning of _____ between 6:30 A.M. and 9:00 A.M.?
   - ☐ yes; please answer the following questions and mail survey form – No stamp required
   - ☐ no; please return survey form without answering questions

2. What intervening stop(s) did you make between the place where this trip began and your final destination?
   - ☐ none ☐ restaurant
   - ☐ babysitter ☐ other(s) (specify) _____

3. Where did this trip begin? (Your home address if this trip started at home)

   Street Address _____

   City _____ State _____ Zip Code _____

4. This address was ☐ home ☐ other (specify) _____

5. Time you began this trip ____ A.M. (left above address)

6. What was the final destination of this trip? *(Physical address* of your work place, if work trip)

   Street address or building name _____

   City _____ State _____ Zip Code _____

7. This address was ☐ work ☐ other (specify) _____

8. Time this trip ended ____ A.M. (arrived at above address)

PLEASE CONTINUE TO QUESTION 9 ABOVE

9. When you made this trip, where did you park your auto?
   - ☐ on the street ☐ in a commercial lot/garage
   - ☐ in a space provided or subsidized by your employer
   - ☐ other (specify) _____

10. What is the vehicle parking cost? (*Don't* divide by the number of persons sharing the parking cost) ☐ not applicable, or $ ____ per day

11. How often do you use *each* of the following means to travel between home and work?
    - a) Driving alone ___ day(s) per week
    - b) Bus ___ day(s) per week
    - c) A carpool ___ day(s) per week

12. Could you have used a bus to make this trip?
    - ☐ yes ☐ no ☐ don't know

13. When was the last time you *regularly* used the bus to commute from your present home to your present work place? ☐ never
    - ☐ not within the last 5 years, or ____ month ____ year

14. When was the last time you *regularly* used a carpool to commute from your present home to your present work place? ☐ never
    - ☐ not within the last 5 years, or ____ month ____ year

15. If you do not now regularly commute from home to work by bus, why not? (Mark one or more of the following)
    - ☐ I now regularly commute by bus
    - ☐ Bus not available
    - ☐ Need car during work day
    - ☐ Bus takes too long
    - ☐ No seats available on bus
    - ☐ Bus unreliable
    - ☐ Too much time spent waiting at bus stops
    - ☐ Too much walking necessary
    - ☐ Bus too expensive
    - ☐ No personal privacy on bus
    - ☐ Other factor(s) (specify) _____

16. If you do not now regularly commute from home to work by carpool, why not? (Mark one or more of the following)
    - ☐ I now regularly commute by carpool
    - ☐ Inability to locate others willing to carpool
    - ☐ Too much time required to pick up and discharge carpool passengers
    - ☐ Too much risk to personal safety
    - ☐ No personal privacy in carpool
    - ☐ Too much auto insurance required
    - ☐ Loss of flexibility in working hours
    - ☐ Need car during work day
    - ☐ Other factor(s) (specify) _____

17. If you could not commute from home to work by driving alone how would you usually make this trip?
    - ☐ would be unable to make this trip ☐ use bus
    - ☐ join or form a carpool ☐ other (specify) _____

18. What are your regular working hours? ☐ no regular working hours, or ____ A.M. to ____ P.M.

19. When was the last time you changed your place of residence? ☐ not within the last 5 years, or ____ month ____ year

20. When was the last time you changed your *physical work location*? ☐ not within the last 5 years, or ____ month ____ year

21. Is an auto available for you to REGULARLY drive alone from home to work?
    - ☐ no ☐ yes, but with considerable inconvenience to others, ☐ yes, and without inconvenience to others

22. How many automobiles are owned or operated by members of your household? ☐ none, or ____ auto(s)

23. Which of the following attitudes best expresses your opinion about driving alone as a way of commuting from home to work?
    - ☐ I am generally satisfied with driving alone as a *long range* solution to my commuting problems.
    - ☐ I am generally satisfied with driving alone as a *short term* solution to my commuting problems until improvements are made in mass transit.
    - ☐ I am generally dissatisfied with driving alone, why _____
    - ☐ Other (specify) _____

24. Please indicate your: *Sex* ☐ Male ☐ Female *Age* ☐ under 21 ☐ 21-39 ☐ 40-65 ☐ over 65

25. What is the combined annual income of all members of your household? ☐ $0-5,000 ☐ $5,001-15,000 ☐ $15,001-30,000 ☐ Above $30,000

26. Any comments? _____

THANK YOU – PLEASE SEAL AND MAIL

EXHIBIT A-9

MINNEAPOLIS SELF-ADMINISTERED BUS SURVEY

Survey is sponsored by U.S. Dept. of Transportation
Please give us a few minutes and we will try to give you better Transportation service.

R. G. Leppaard
Commissioner of Highways

Chairman, Metropolitan Transit Commission

OMB 04-R5637

1. I got on this bus at _____ (Nearest Street Corner)

2. The place I have come from is: _____ (Address or Street Intersection) Home? ☐ YES ☐ NO

3. The place I am going to is: _____ (Address, Building or Street Intersection) Work? ☐ YES ☐ NO

4. I began this trip at about _____ A.M.; and arrived at my destination about _____ A.M.

5. What are your regular working hours? _____ A.M. to _____ ☐ A.M. ☐ P.M.

6. How did you get to this bus?

☐ Walked _____ Blocks ☐ Drove Auto ☐ Auto Passenger
☐ Drove Auto/Parked ☐ Bus (Route No. _____) ☐ Other _____ (Specify)

7. After leaving this bus, how will you complete your trip?

☐ Walk _____ Blocks ☐ Bus (Route No. _____) ☐ Other _____ (Specify)

8. On an average day when you board the bus, do you find a seat?

☐ Always ☐ Usually ☐ Seldom ☐ Never

9. How did you make this trip prior to using this bus?

☐ Drove my car (_____ passengers) ☐ An auto passenger
☐ Alternate driver in car pool ☐ Used another bus (Route No. _____)
☐ Did not make trip

10. If you formerly traveled by car, what is the major reason you switched to the bus?

☐ Cheaper ☐ Safer ☐ Less Travel Time ☐ More Dependable ☐ Other _____ (Specify)

11. During Monday through Friday, how often do you normally ride the bus?

☐ Ride every day ☐ 3 or 4 days ☐ 1 or 2 days ☐ Very rarely

12. How long have you been using this bus?

_____ Years _____ Months

13. If one transit improvement could be made, which of the following would you select? (Check only one)

☐ Lower Fare ☐ More Extensive Service (Less walking)
☐ More Frequent Service ☐ Less Traveling Time
☐ More Comfortable Vehicle ☐ No Need to Transfer
Other _____ (Specify)

14. How would you rate your general attitude toward traveling to work by bus?

☐ Very positive ☐ Positive ☐ Negative ☐ Very negative

Now, just a few questions for statistical purposes:

15. How long have you lived at your present home address? _____ Years _____ Months

16. How many autos are owned or operated by members of your household?

☐ None ☐ One ☐ Two ☐ More than two cars

17. Was a car available to you for this trip?

☐ No (bus is only practical way)
☐ Yes (but with inconvenience)
☐ Yes (but I prefer the bus)

18. Are you: ☐ Male ☐ Female What is your age? _____

19. Are you a licensed driver? ☐ Yes ☐ No

20. My combined annual family income is:

☐ Under $3,000 ☐ $5,000-$7,999 ☐ $10,000-$11,999 ☐ $15,000-$19,999 ☐ $25,000-$29,999
☐ $3,000-$4,999 ☐ $8,000-$9,999 ☐ $12,000-$14,999 ☐ $20,000-$24,999 ☐ $30,000 or more

THANK YOU·····Please seal and mail

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EXHIBIT A-10

RECOMMENDATIONS FOR QUESTIONS ON BOARDING AND ALIGHTING POINTS
(For User Surveys Only)

QUESTION FORMAT

1. "Where did you board this (vehicle)?"

   _____
   Nearest Street Intersection

2. "Where will you (did you) get off this (vehicle)?"*

   _____
   Nearest Street Intersection

RESPONSE CATEGORIES

Respondent should specify nearest street intersection. Coders can then translate street address to codes representing bus stops or, if a less fine-grained analysis is required, zonal codes.

COMMENTS

Question format contains parentheses to indicate where site-specific modes might be substituted.

*The use of "will you" or "did you" depends on whether the survey is filled out while the respondent is on board the vehicle or completed later and returned by mail.

EXHIBIT A-11

RECOMMENDATIONS FOR QUESTIONS ON TRIP ORIGIN

QUESTION FORMAT

1a. "Where did this trip begin?"

_____
Street Address, City, Zip Code

2. "Is this place --- (check one)"

- ☐ Home
- ☐ Place of employment
- ☐ School
- ☐ Retail/commercial establishment
- ☐ Social-recreational facility
- ☐ Medical facility
- ☐ Personal business site
- ☐ Other (specify) _____

RESPONSE CATEGORIES

Use categories given under "Question Format" or, if the main purpose of the question is to distinguish work vs. nonwork trips, use the following categories:

- ☐ Home
- ☐ Place of employment
- ☐ Other

Respondent should specify street address. Coders can then translate street address to zonal codes, or addresses can be geocoded using the Census Bureau's DIME files and ADMATCH program.

Another option, for interview surveys, is to have the interviewer show the respondent a map with numbered zones superimposed and ask the respondent to identify the origin zone.

COMMENTS

The question classifying nature of trip origin, in combination with a question classifying nature of trip destination, is a better indication of trip purpose than a question explicitly asking trip purpose, which can be confusing to persons making multiple-purpose trips.

EXHIBIT A-12

RECOMMENDATIONS FOR QUESTIONS ON TRIP DESTINATION

QUESTION FORMAT

1. "What is (was) the final destination of this trip?"

   _____

   Street Address, City, Zip Code

2. "Is this place --- (check one)"

   ☐ Home
   ☐ Place of employment
   ☐ School
   ☐ Retail/commercial establishment
   ☐ Social-recreational facility
   ☐ Medical facility
   ☐ Personal business site
   ☐ Other (specify) _____

RESPONSE CATEGORIES

Use categories given under "Question Format" or, if the main purpose of the question is to distinguish work vs. nonwork trips, use the following categories:

☐ Home
☐ Place of employment
☐ Other

Respondents should specify street address. Coders can then translate street addresses to zonal codes, or addresses can be geocoded using the Census Bureau's DIME files and ADMATCH program.

Another option, for interview surveys, is to have the interviewer show the respondent a map with numbered zones superimposed, and ask the respondent to identify the destination zone.

COMMENTS

The question classifying nature of trip destination, in combination with a question classifying nature of trip origin, is a better indication of trip purpose than a question explicitly asking trip purpose, which can be confusing to persons making multiple-purpose trips.

EXHIBIT A-13

RECOMMENDATIONS FOR QUESTIONS ON
TRIP START AND END TIMES

QUESTION FORMAT

1. "What time did you begin this trip?"
   _____ A.M.
   _____ P.M.

2. "What time did you arrive at your destination?"
   _____ A.M.
   _____ P.M.

RESPONSE CATEGORIES

Depending on the survey objectives, beginning/ending times can be used as given to compute total trip times, or they can be coded using categories such as A.M. peak, midday, P.M. peak, nighttime.

* With personal interviews onboard vehicles, it is not possible to ask time of arrival at destination.

EXHIBIT A-14

RECOMMENDATIONS FOR QUESTIONS ON ACCESS MODE TO TRANSIT VEHICLE

QUESTION FORMAT

1. "How did you get from the place where this trip began to the (place) where you boarded this (vehicle)?"

2. "How will you (did you) get to your destination after leaving this (vehicle)?"*

RESPONSE CATEGORIES

U.S. Census	Recommended
Private auto, driver	Park 'n' ride
Private auto, passenger	Carpool
	Kiss 'n' ride
Bus or streetcar	Same (if relevant, add dial-a-ride)
Subway, elevated train, railroad	Same
Walked	Same
Worked at home	Omit
Taxi	Same
Bicycle or motorcycle Other	Other

COMMENTS

Question format contains several parentheses to indicate where site-specific modes and locations might be substituted to make the question more relevant. The same principle applies to the recommended response categories; the above list is suggestive and needs to be adjusted to site-specific concerns such as measuring the number of auto passengers for evaluation of a carpool encouragement program.

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*The use of "will you" or "did you" depends on whether the survey is filled out while the passenger is on board the vehicle or is completed later and returned by mail.

EXHIBIT A-15

RECOMMENDATIONS FOR QUESTIONS ON WHEN PRESENT MODE WAS FIRST USED

QUESTION FORMAT

For User Surveys

"When did you begin to use (specify service) regularly for the trip you are now taking?"

☐ not applicable, or

_____month _____year

For Non-user Surveys

"When was the last time you regularly used (specify service) for the trip you are now taking?"

☐ not within the last 5 years, or

_____month _____year

For Non-user Surveys in Which Carpoolers and Those Who Drove Alone are Given Separate Questionnaires

For Carpoolers:

"When did you begin to regularly use this carpool for the trip you are now taking?"

☐ not applicable, or

_____month _____year

For Those Who Drove Alone:

1. "When was the last time you regularly used (specify service) for the trip you are now taking?"

☐ not within the last 5 years, or

_____month _____year

2. "When was the last time you regularly used a carpool for the trip you are now taking?"

☐ not within the last 5 years, or

_____month _____year

EXHIBIT A-15 (CONT.)

RESPONSE CATEGORIES

Use categories given under "Question Format".

COMMENTS

It is confusing to ask auto users who drive alone when they began to regularly drive alone in taking their present trip. Therefore, they should be asked when they last regularly used other modes in taking their present trip.

EXHIBIT A-16

RECOMMENDATIONS FOR QUESTIONS ON FORMER TRANSPORTATION MODE

QUESTION FORMAT

"How did you make this trip before (specify service) was available?"

RESPONSE CATEGORIES

U.S. Census	Recommended
Private auto, driver	Same (indicate total number of occupants)
Private auto, passenger	Same (indicate total number of occupants)
Bus or streetcar	Same
Subway, elevated train, railroad	Same
Walked	Same
Worked at home	Omit
Taxi	Same
Bicycle, motorcycle Other	Other

COMMENTS

The responses will have to be tailored to include particular local transportation alternatives. For instance, it might be desirable to obtain information on former auto occupancy levels for ex-drivers/passengers.

Examples of attitudinal questions appear throughout the aforementioned Exhibits A-3 through A-9, and also in Exhibits A-17 and A-18. The set of questions in Exhibit A-17 can be used both to measure users' and non-users' evaluations of the transit service provided and the factors that have influenced their modal choices. This set of questions can also be used to learn about the opinions of the general population regarding travel by alternate modes. Note that respondents are asked not only for opinions about different travel characteristics bus for a ranking of the relative importance of these characteristics. The latter set of questions is needed to put the respondents' opinions about the different travel characteristics into proper perspective. For example, if several respondents indicated that "car" had a very high status and "bus" had a very low status, it might at first appear that the status of the automobile might deter the use of bus transit. However, the responses would be considerably less significant if these same respondents indicated that the "status" travel characteristics was rather unimportant to them. The set of attitudinal questions in Exhibit A-18 can be used to obtain a profile of the community in which transit service is being provided.

There are no specific recommendations for the format of attitudinal questions, since the design of such questions is entirly dependent on the particular attitudes being measured (e.g., opinions of a very subjective item or perceptions about items which are independently measurable) and on the overall survey context. However, the following discussion presents some general informative guidelines regarding the treatment of responses to attitudinal questions.

There are three types of response categories which can be used for attitudinal questions: nominal, ordinal, and interval scales. Nominal data consists of mutually exclusive categories with no implied rating of the responses (e.g., questions with "yes","no" answers). Responses such as "like very much," "dislike," "dislike very much" represent ordinal level data, with an implied rank ordering. Interval data involves the use of numerical scales (e.g., asking people to indicate their opinions on a scale of 1 to 5). Since interval scales require prior validation and careful application, it is recommended that attitudinal questions be limited to nominal or ordinal response categories. Moreover, it is recommended that the survey data be represented in the form of frequency distributions, rather than statistics such as means which have an implied ranking.

EXHIBIT A-17

SET OF ATTITUDINAL QUESTIONS ON TRAVEL BY TRANSIT AND AUTO

YOUR OPINION OF TRAVEL BY DIFFERENT MODES

4. On the scales below, please indicate your general opinion of car and bus travel for local travel. Base your opinion on what you have experienced or have heard about local travel by each mode from the user's viewpoint. Even though you may not use the bus, you probably have some perceptions of what this form of travel is like; you don't need to have tried something in order to be able to express some general opinions.

   To indicate your opinion, look at the descriptive scales below, each of which allows for a range of opinions on a particular characteristic, such as COMFORT. Then, mark what you consider to be the single most appropriate description on each scale by circling the relevant number. For instance, on the COMFORT scale, if you thought cars were a very comfortable form of travel for local travel, you would circle "1" on the scale on the line for cars; however, if you thought they were a slightly uncomfortable form of travel, you would circle "4", and so forth.

TRAVEL CHARACTERISTICS			Very (1)	Slightly (2)	Neither or Both Equally (3)	Slightly (4)	Very (5)	
COST OF TRAVEL	Inexpensive	Car	1	2	3	4	5	Expensive
		Bus	1	2	3	4	5	
ENJOYABLENESS	Enjoyable Form of Travel	Car	1	2	3	4	5	Unenjoyable Form of Travel
		Bus	1	2	3	4	5	
SPEED ON NON-COMMUTE TRIPS	Fast	Car	1	2	3	4	5	Slow
		Bus	1	2	3	4	5	
CONVENIENCE	Convenient Form of Travel	Car	1	2	3	4	5	Inconvenient Form of Travel
		Bus	1	2	3	4	5	
STATUS	High Status Form of Travel	Car	1	2	3	4	5	Low Status Form of Travel
		Bus	1	2	3	4	5	
SPEED ON COMMUTE TRIPS	Fast	Car	1	2	3	4	5	Slow
		Bus	1	2	3	4	5	
COMFORT (Seats, Noise, Ride, etc.)	Comfortable	Car	1	2	3	4	5	Uncomfortable
		Bus	1	2	3	4	5	
MODERNITY	Modern Form of Travel	Car	1	2	3	4	5	Old-Fashioned Form of Travel
		Bus	1	2	3	4	5	
SAFETY	Safe Form of Travel	Car	1	2	3	4	5	Dangerous Form of Travel
		Bus	1	2	3	4	5	
SIMPLICITY	Simple to Use	Car	1	2	3	4	5	Complicated to Use
		Bus	1	2	3	4	5	
PUNCTUALITY	On-Time Arrivals	Car	1	2	3	4	5	Late Arrivals
		Bus	1	2	3	4	5	

EXHIBIT A-17 (CONT.)

YOUR RANKING OF THE RELATIVE IMPORTANCE OF THE DIFFERENT TRAVEL CHARACTERISTICS

Listed below are the set of travel characteristics which appeared in the previous question. In the blanks next to each characteristic, please indicate how important that characteristic is in your decision to use car or bus for local travel, by placing one of the following "importance" numbers in the blank:

3 - Very important
2 - Moderately important
1 - Unimportant, or don't consider it

_____ Cost of Travel

_____ Enjoyableness

_____ Speed on non-commute trips

_____ Convenience

_____ Status

_____ Speed on commute trips

_____ Comfort, (seats, noise, ride, etc.)

_____ Modernity

_____ Safety

_____ Simplicity

_____ Punctuality

EXHIBIT A-18

SET OF QUESTIONS ON GENERAL ATTITUDES OF THE POPULATION

YOUR OPINIONS ABOUT LOCAL GOVERNMENT

Everyone has different ideas about the kinds of things local government should be most concerned about. Below is a list of different things the government might do. Please indicate your feeling about how much the government should do of each activity.

Government Activities	Much more	Slightly more	About the same	Slightly less	Much less
i) Reduce crime.	M	m	s	l	L
ii) Reduce environmental pollution.	M	m	s	l	L
iii) Provide low-cost medical care for all . .	M	m	s	l	L
iv) Control population growth	M	m	s	l	L
v) Provide more housing for low to medium income families	M	m	s	l	L
vi) Insure equal opportunity for women. . . .	M	m	s	l	L
vii) Provide consumer protection	M	m	s	l	L
viii) Add to and improve the freeway system . .	M	m	s	l	L
ix) Increase direct aid to the poor	M	m	s	l	L
x) Improve bus service and other forms of public transportation	M	m	s	l	L
xi) Have more parks and outdoor recreation areas	M	m	s	l	L
xii) Improve the public schools.	M	m	s	l	L
xiii) Reduce taxes.	M	m	s	l	L

(a) Which one of the activities do you feel is the most important for the government to do? Just give the letter.

Most important _____

(b) And which do you feel is the next most important?

Next most important _____

EXHIBIT A-18 (CONT.)

YOUR OPINIONS ON TRANSPORTATION AND PERSONAL TRAVEL

Below are listed a number of statements relating to transportation facilities and personal travel; you will probably agree with some of them and disagree with others. Please answer by circling the letter which best represents your feeling about each of the statements, according to the following codes:

A means Strongly Agree	a means Agree Somewhat	o means neither Agree nor Disagree	d means Disagree Somewhat	D means Strongly Disagree

I much prefer driving a car to being a passenger in one.....A a o d D

It's time measures were taken to discourage auto usage in downtown _____.....A a o d D

I really can't see much of a future for public transportation.....A a o d D

I could manage without a car for a few months if I had to.....A a o d D

People would use public transportation a lot more if fares were lower.....A a o d D

I'd much rather people saw me arriving at work by car than getting off a bus.....A a o d D

I've never really bothered to find out details of what public transportation services are available around here.....A a o d D

A lot of my friends and acquaintances judge people by the type of car they drive...A a o d D

It's important that my home be close to good public transportation services.....A a o d D

Government investments in mass transit are a good way to help reduce air pollution.A a o d D

I've got bad memories of public transportation.....A a o d D

Everyone has a right to drive his car just as much as he wants.....A a o d D

Public transportation is no use at all for journeys outside commute hours.....A a o d D

I enjoy driving very much.....A a o d D

It would hardly seem proper for someone in a top job to commute by bus.....A a o d D

I hate to be tied to fixed schedules for traveling.....A a o d D

I might use public transportation more often if it were simpler to obtain information about routes and schedules.....A a o d D

Traveling by public transportation is so much more relaxing than driving.....A a o d D

I often worry about being involved in a bad car accident.....A a o d D

I'd never travel regularly by any form of public transportation, no matter how much they improved the service.....A a o d D

The idea of carpooling doesn't appeal to me.....A a o d D

There should be a greater emphasis on developing improved public transportation systems and less on building freeways.....A a o d D

I'm always glad of an excuse to take my car out for a drive.....A a o d D

In the past, methods for categorizing responses to attitudinal questions have been varied and inconsistently applied. Accordingly, these guidelines cannot offer a preferred means of categorization for each measure which might arise. As more experience is gained in this area through independent research* and future demonstrations, TSC will attempt to develop a consistent approach toward the application of attitudinal measures and the categorization of responses.

(3) Social and Demographic Measures

The inclusion of certain social/demographic questions in surveys serves the dual purpose of 1) providing data on respondent characteristics which might show a correlation (perhaps even a causal relationship) with measured behavioral attributes, and 2) providing data about respondents which can be used in conjunction with Census data to check survey accuracy, determine non-response bias, and extrapolate survey findings to other areas.

The amount and nature of social/demographic information collected depends on a number of factors, in particular, the desired length of the survey and the extent to which the data will be correlated with behavioral data and used for extrapolation purposes. It is recommended that the following items be included in every survey: respondent's sex, age, household income, the number of autos in the respondent's household, and availability of an auto for the particular trip(s) made on transit (user surveys only). Depending on the survey objectives, scope, and administration format, the following are some of the additional items which might be included: whether the respondent has a driver's license, the general (regular) availability of an auto for a particular trip type (e.g., work), educational level completed, occupation, and length of residence and employment at present location.

Examples of questions on social/demographic variables appear throughout Exhibits A-3 through A-9. Exhibits A-19 through A-28 present the recommended question format and

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*For example, the forthcoming UMTA/TSC-sponsored research on the predictive validity of attitudinal surveys should be helpful in this regard.

EXHIBIT A-19

RECOMMENDATIONS FOR QUESTIONS ON RESPONDENTS' SEX

QUESTION FORMAT

A. For Self-Administered Surveys

"Are you ---

☐ Male ☐ Female

or

"Please indicate your sex"

☐ Male ☐ Female

B. For Interview Surveys

Respondent's sex is noted by the interviewer.

EXHIBIT A-20

RECOMMENDATIONS FOR QUESTIONS ON RESPONDENT'S AGE

QUESTION FORMAT

"To what age group do you belong?"

RESPONSE CATEGORIES

U.S. Census	Recommended
Under 5	Under 20
5-9	
10-14	
15-19	
20-24	20-44
25-29	
30-34	
35-39	
40-44	
45-49	45-64
50-54	
55-59	
60-64	
65-69	65 and over
70-74	
75-79	
80-84	
85 and over	

COMMENTS

The recommended response categories represent the minimum stratification of data to be collected about age. Age responses can be further stratified according to the U.S. Census categories, depending on the survey objectives and the expected age distribution of the respondent population.

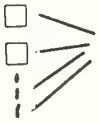
It is important to use the phrase "age group" in all questions about age to minimize the respondent's resistance to this question.

EXHIBIT A-21

RECOMMENDATIONS FOR QUESTIONS ON RESPONDENT'S INCOME

QUESTION FORMAT

"What is the combined annual income of all members of your household?"



RESPONSE CATEGORIES

U.S. Census	Recommended
Less than $1,000	Less than $5,000
$1,000 - 1,999	
$2,000 - 2,999	
$3,000 - 3,999	
$4,000 - 4,999	
$5,000 - 5,999	$5,000 - 9,999
$6,000 - 6,999	
$7,000 - 7,999	
$8,000 - 9,999	
$10,000 - 14,999	$10,000 - 14,999
$15,000 - 24,999	$15,000 - 24,999
$25,000 and over	$25,000 and over

COMMENTS

The recommended response categories represent the minimum stratification of income data. Responses can be further stratified according to the U.S. Census categories, depending on the survey objectives and the expected income distribution of the respondent population.

For interview surveys, asking a respondent to point to one of the above categories on a card facilitates handling of this often sensitive question.

It is important to use the word "annual" or "yearly" in order to obtain responses on a consistent basis. Moreover, if deemed appropriate, the question can be phrased to refer to the most recently ended calendar year.

EXHIBIT A-22

RECOMMENDATIONS FOR QUESTIONS ON AUTO AVAILABILITY
(For User Surveys Only)

QUESTION FORMAT

"Was a car available to you for this trip?"

RESPONSE CATEGORIES

"Was a car available....?"

- ☐ Yes, and without inconvenience to others.
- ☐ Yes, but with inconvenience to others.
- ☐ No.

COMMENTS

Information on the availability of a car for a specific trip or time period is the most direct way of determining auto availability and its possible influence on mode used.

EXHIBIT A-23

RECOMMENDATIONS FOR QUESTIONS ON AUTO OWNERSHIP

QUESTION FORMAT

"How many cars are owned or operated by members of your household?"

RESPONSE CATEGORIES

U.S. Census	Recommended
0 cars	☐ None, or _____ auto(s)
1 car	
2 cars	
3 or more cars	

EXHIBIT A-24

RECOMMENDATIONS FOR QUESTIONS ON WHETHER RESPONDENT HAS DRIVER'S LICENSE

QUESTION FORMAT

"Are you a licensed driver?"

RESPONSE CATEGORIES

"Are you ...."

☐ Yes ☐ No

EXHIBIT A-25

RECOMMENDATIONS FOR QUESTIONS ON RESPONDENT'S OCCUPATION

QUESTION FORMAT

1. "Are you _____"

   ☐ Employed

   ☐ Student

   ☐ House Spouse

   ☐ Retired

   ☐ Other

2. "If you are employed, describe briefly the kind of work you do."

   _____

   _____

CODING CATEGORIES FOR QUESTION 2

U.S. Census	Recommended
Professional, technical and kindred workers Managers and administrators, except farm Salesworkers Clerical and kindred workers Craftsmen and kindred workers Operatives, except transport Transport equipment operatives Laborers, except farm Farmers and farm managers Farm laborers and farm foremen Service workers, except private household Private household workers	The survey form should contain a blank space for an open-ended description which can later be coded using the U.S. Census occupational categories.

COMMENTS

Question 2 should be included in the survey only when there is a very specific reason for using employment data. In order to perform the coding for question 2, it is necessary to obtain a description of the type of work actually done as well as job title.

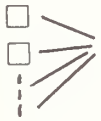
EXHIBIT A-26

RECOMMENDATIONS FOR QUESTIONS ON RESPONDENT'S EDUCATIONAL LEVEL

QUESTION FORMAT

For All Surveys

"What is the last grade (or year) of regular school you (he/she) attended?"



(asked for each household member in dwelling unit survey)

RESPONSE CATEGORIES

U.S. Census		Recommended
None		No Formal Schooling
1-4		Grade School
5-7		Grade School
8		Grade School
High School:	1-3	Some High School
	4	High School Degree
College:	1-3	Some College
	4 years or more	College degree or higher

EXHIBIT A-27

RECOMMENDATIONS FOR QUESTIONS ON LENGTH OF RESIDENCE

QUESTION FORMAT

"When did you (your household) move to your present residence?"

RESPONSE CATEGORIES

U.S. Census*	Recommended
1969-70	☐ Not within the last 5 years, or
1968	
1967	_____ month _____ year
1965-66	
1960-64	
1950-59	
1949 or earlier	

COMMENTS

The recommended response categories represent the minimum stratification of data to be collected about length of residence. Responses can be further stratified (for greater than 5 years), depending on the survey objectives and the expected residency level distribution of the respondent population.

*The U.S. Census categories reflect the year of the Census, 1970.

EXHIBIT A-28

RECOMMENDATIONS FOR QUESTIONS ON
TRIP PRODUCTION RATES

QUESTION FORMAT

"Please indicate what trips you have recently taken."

RESPONSE CATEGORIES

Trip Purpose	Yesterday	Day before Yesterday	The day Before That
Work			
School			
Shopping			
Social-Recreational			
Medical-Dental			
Personal Business			
Other			

(Count the number of one-way trips you took under each purpose. If you went shopping and then returned home, that is two (2) shopping trips. If you took a trip with multiple purposes count it under the principal purpose of the trip and mark a check (✓) for any other purposes served.)

response categories for most of the social/demographic measures listed above. The recommended categories deliberately parallel U.S. Census categories where possible. It is considered important to collect and code this type of data in categories which are equivalent to, or collapsible into, Census categories, so as to facilitate comparisons with the same type of Census data for the survey area (for accuracy check purposes)*, or to permit the use of other types of Census data to amplify survey findings (with the collected data serving as a bridge between the survey population and the Census population). Special purpose surveys may require a greater amount of detail about a particular social/demographic measure, but the stratification should be compatible with commonly used Census breakdowns.**

6. NON-RESPONSE BIAS

Use of the guidelines presented in this Appendix to design and execute a survey does not insure that the responses obtained will accurately reflect the characteristics, travel behavior, and/or attitudes towards the demonstration project service of the entire sample selected even though the sample itself is unbiased and totally representative of the population from which the sample was selected. It is possible that the characteristics, behavior, and attitudes of the part of the sample that did not respond to the survey are different from those of the part that did respond, hence producing non-response bias.

Pretesting of the survey instrument may or may not reveal this problem when it exists. Even if pretesting does reveal the problem, there may be no effective means of eliminating it. This is especially true if there is a

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*Census tract or block data on family income will be a good check on reporting accuracy.

**See U.S. Census, Volume I: Characteristics of the Population, Part II, Appendix B for a detailed discussion on format of questions. See also "1970 Census User Guide," U.S. Department of Commerce, Bureau of the Census, Washington, D.C., June, 1969.

systematic refusal to participate in a survey by certain segments or personality types in the population. It is recommended here that an attempt be made in every survey to determine whether or not non-response bias exists and how it might affect the validity of results.

There are no specific guidelines for ascertaining the existence of non-response bias. In general, non-respondents can be reached with a very short survey containing but a few key questions that is administered with considerable personal contact. Where non-respondents cannot be identified, the special survey would be given with the regular survey to a part of the sample. Many of those who do not respond to the regular survey will respond to the special survey. Where non-respondents can be identified after the regular survey has been completed, only they would be given the special survey. The responses of respondents and non-respondents to the few key questions can then be compared to determine whether the responses of respondents and non-respondents are significantly different, and therefore, whether non-response bias exists.

The contractor should attempt to devise a specific methodology for determining whether non-response bias exists in the survey responses obtained from the surveys being conducted.

7. INTERVIEWS WITH TRANSIT COMPANY PERSONNEL

There are situations where it may be useful to conduct interviews with transit company personnel, e.g., drivers, mechanics, management. In some cases, such interviews could be used to develop ideas for questions and sets of responses for surveys of users and non-users. This is useful in situations where changes are being hypothesized, and transit company personnel could give their opinions and insight on measuring these potential changes.

In other cases, such interviews could be used to check the validity of collected data and survey responses. In some very specific cases, such interviews could provide first-hand data on certain project characteristics. For example, drivers and mechanics could provide information on the operating and maintenance characteristics of an innovative vehicle, e.g., double deck bus. Management could provide insight into the labor problems associated with operating a handicapped and elderly project. Dispatchers could provide insight into the operating characteristics of

a demand-responsive system. The situations discussed are not meant to be all-inclusive. No specific guidelines have been put forth. It is up to the contractor to decide whether interviews with transit company personnel would provide information needed to perform the particular evaluation, and to design the appropriate survey technique.

APPENDIX B

STATISTICAL METHODOLOGY

This Appendix presents guidelines relevant to determining appropriate sample sizes for data collection as well as the subsequent analyses based on sample data.

The determination of appropriate sample sizes and data analysis requirements is a crucial aspect of planning for data collection, since in general this phase involves scoping the level of activity related to collection of project-specific measures. Just as failure to plan the basic evaluation approach will mean not having the proper framework in which to observe and evaluate the demonstration, failure to plan or improper planning of sample size requirements and data analysis procedures will threaten the ultimate statistical validity and usefulness of project results. An insufficient quantity of data (whether due to no planning, i.e., haphazard data collection, or to an underestimate of needs) will be manifested in the loss of potentially valuable analyses and/or a loss in accuracy and validity of the analyses based on the data. On the other hand, excessive quantities of data will mean the unnecessary expenditure of funds and possibly the sacrifice of other data items which could be useful but which are beyond a constrained budget. The ideal is to obtain an appropriate balance between analysis requirements and resource availability. It should be remembered that small samples, if they are well planned, can yield useful and interpretable data.

1. DEFINITIONS

To assure a complete understanding of the concepts presented in this Appendix, as well as those identified in the references thereto, the following terms are identified:

(1) Observational entity or element - An individual item in a set of items or responses, each of which is identifiable by one or more measures. Examples of observational entities are automobiles, vehicles, persons, time periods.

(2) Population or universe - A finite or perhaps very large collection of observational entities. A population is usually a group about which

inferences are desired. Examples of populations would be all those vehicles on a corridor leading to the central business district during AM peak periods, all those persons within 15 minutes access time of the transit system, or all users of a service.

(3) Sample - A finite subset of observational entities drawn from a population. Samples can be drawn by appropriate procedures which will permit inferences to the population from which the sample was drawn or they may be obtained by non-controlled devices. Examples of samples would be some of the vehicles passing a given screen-line during a specific time period, or a subset of those individuals within a service area.

(4) Observation - One or more measures which describe the observational entities included in the sample either directly or derived from measurements, such as travel times or passenger counts.

(5) Population parameter - A specific descriptive characteristic of a population assumed to be constant at any moment or period in time.

(6) Sample statistic - A summary value obtained from a sample observation, usually descriptive of the sample but desired for purposes of making inferences about the population or changes in the population parameter.

2. DATA ANALYSIS DETERMINATION

It should be evident that the intent of using samples is to make inferences about changes in transit system characteristics or in the attitudinal/behavioral characteristics of the community being served.

Before estimating sample size requirements, it is necessary to determine the appropriate types of analyses to be performed (i.e., What will be done with the data once it has been collected?). Types of statistical analyses which can be performed are numerous. As a general guideline, it is essential that the evaluations for SMD projects be confined to fairly fundamental types of analyses--i.e., involving the calculation of means, standard deviations or variances, proportions, ratios, and ranges. Suggested

statistical techniques for performing these analyses are discussed later in this Appendix.

It should be noted that more sophisticated statistical methods, such as multiple regression, factor analysis, and discriminant analysis, while highly useful in a theoretical sense, may not be applicable in the current generation of SMD projects. As more experience is gained with the data collected during these demonstrations, it may be possible to institute some of the referenced multivariate techniques.

The use of a simple analytical framework will have three main advantages: (1) the results will be expressed in numerical terms that have a direct relation to specific project objectives; (2) the evaluation results will be meaningful to a wide audience; and (3) the results of a particular demonstration can be more easily compared with those of other projects.

The types of statistical analyses which can be performed and the appropriate equations and tables to be used in performing these analyses and determining sample sizes are presented in an organized, thoroughgoing manner in M.G. Natrella, Experimental Statistics, National Bureau of Standards Handbook 91, August 1, 1963.* Included in this handbook are procedures for estimating average performance from a sample, estimating variability of performance for a sample, comparing two or more samples with respect to average performance or variability of performance, characterizing the functional relationship between two variables, and comparing samples with respect to discrete classifications such as income, mode of travel to work, etc. Two other excellent references are given at the end of this Appendix. Since most of the specific equations to be employed in dealing with these situations are clearly presented in Natrella and other commonly used statistics reference books, the remainder of this section will be devoted primarily to a discussion of some of the statistical considerations by the contractor.

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*The contractor is encouraged to obtain a copy of this book, since it is referenced throughout this section of the guidelines as a source for tables, equations and other materials.

Of the numerous cases presented in Natrella, the following basic set of underlying questions is considered applicable for SMD evaluations:

If estimates of population parameters only are required:

(1) What is an estimate for the average value (mean) of the measure (let X represent the measure)?

(2) What is an estimate for the variability (variance or standard deviation) of the measure?

(3) What is an estimate of the proportion of units that have a given characteristic?

If comparisons between two groups (e.g., before vs. after; test vs. control) are involved:

(1) What is the difference between the average value of the measure, X, for group A and the average value of the measure, X, for group B?

(2) Same question as (1) except applied to the variability of the measure in groups A and B.

(3) Same question as (1) except applied to proportions of some discrete measure in groups A and B.

The same types of questions can be phrased when there are more than two groups (time periods) involved in the comparisons. Here, however, the methods for analysis become more complex, and greater care must be exercised in selecting and applying statistical techniques.

In connection with addressing the question "What is the value...? or "What is the difference...?", it is recommended that results be given in terms of confidence intervals rather than tests of significance. By presenting a confidence interval (an interval which contains the true parameter, or difference between two parameters, with a known probability), the decision-maker can interpret the magnitude of this interval whether it be for an estimate of a population parameter or for the difference between two parameters. On the other hand, if a test of significance is used, the interpretation of non-significance and significance becomes somewhat more difficult in terms of relating these inferences back to the project objectives. In some instances where sample sizes are fairly large, differences that can be significant from a statistical viewpoint, may have little practical significance attached

to them. Statements on statistical significance may be made but the practical implications must be considered.

It will generally be adequate for the contractor to report two-sided confidence intervals for a stated confidence level.

3. SAMPLE SIZE DETERMINATION

As long as appropriate sampling methods are applied, the accuracy of a statistic computed from a sample will be greater with a larger sample size. However, this relationship can be one of diminishing returns for very large sample sizes. Moreover, there is a cost, in time and money, which serves as a constraint on sample sizes in each demonstration project. The key aspect of sample size determination is finding the proper balance between desired accuracy and cost: on the one hand, the sample should not be so small that the results lack the required accuracy; conversely, the sample should not be wastefully large.

In Chapter III, Section D, variable stratification (the categorization of collected data by such factors as time of day) was discussed. It was mentioned that the data collection activities should be planned with the finest level of stratification consistent with constraints of time, cost, and acceptable accuracy and confidence. It is important that this determination of desired level of stratification be made as early as possible, since, from the statistical point of view, the sampling plans must include sufficient data in each category of interest for which cross-tabulations are to be performed. The formulas for determining sample size must be applied with respect to each category, so that the appropriate quantity of data is collected for each one. Clearly, an attempt at further stratification after the data has been collected would reduce the accuracy and/or confidence associated with these new sub-stratifications.

The appropriate sample size formula depends on the type of statistical analysis to be performed. Sample size formulas applicable for calculating means, variances, proportions, etc., are given in the references at the end of this Appendix, so the following discussion will be somewhat general. The sample size calculation process should be viewed as providing input for the broad scoping and planning of the data collection effort. The specific sample size values obtained from the formulas should be taken as rough

indications of lower limits for data collection, rather than as precise targets or cut-off points. Prudent expansion factors should be applied to the calculated sample size values so that the ultimate amount of usable data (i.e., the net sample size after the collection activities and editing) is sufficient to yield results with the desired level of precision and statistical accuracy, and allows for unforeseen stratification. As data is collected, it should be possible to modify sample requirements for subsequent phases of a project.

As has been mentioned earlier, it is desired to have results presented in the form of confidence intervals. Determining the sample size for calculating a confidence interval requires three input factors:

(1) The desired confidence level
(2) An estimate of the variablility in the population
(3) The desired precision of the results.

The confidence level of a statistical calculation ($1-\alpha$) can be defined as the proportion of samples of size n for which the calculated confidence interval may be expected to contain the true value of the population parameter being estimated. For purposes of obtaining a conservative sample size estimate, it is recommended that the value $\alpha = .05$ be used.

An estimate for variability is usually taken as the standard deviation. It is desirable initially for this value to be an overestimate to allow for a conservative determination of sample size. While it is preferable to have some prior knowledge about the variability of those measures to be collected, Natrella (pages 2-8 to 2-10) gives an excellent approach for cases where the true standard deviation is unknown.

Determination of an acceptable level of precision is perhaps the most difficult input factor. In the case of estimating means, variability measures, and proportions, the task is to determine the acceptable accuracy, say d, for each confidence interval. The sample size calculated on the basis of a prescribed d and $\alpha = .05$, reflects an acknowledged (permissible) risk that 5 times in 100 the real precision will be worse than d. In the case of estimating the difference between means or between other statistics, the analogous task is to specify the absolute value of a minimum desired detectable average difference δ. Here, too, if $\alpha = .05$, then the sample size will reflect an acknowledged risk that 5 out of 100 times the true

difference between the two groups being compared will exceed δ.

In establishing values for d and δ, consideration must be given to the problem of trading off the cost vs. benefits of increased precision. The cost of increased accuracy can be seen as the marginal amount of time and money needed to collect an additional sample unit. The benefits of increased accuracy can be viewed in terms of additional confidence in the results of a particular project and the consequent willingness of UMTA to make policy and funding recommendations on the basis of these results. Clearly, UMTA does not want to encourage cities to implement service and methods innovations which have only a negligible impact on the quality or usage of transit service; this would argue in favor of setting relatively large values of d and δ. On the other hand, there is a desire to learn whatever possible about the effects of implementing new techniques; if the minimum detectable difference is set too large, the resultant sample size may be too small to detect the existence of minor, possibly unanticipated changes which might be of interest. Given the somewhat different emphasis of exemplary vs. experimental demonstrations, a suggested approach is to consider using smaller values of d and δ in the latter type of project, where the nature of the outcome is less certain.

Working with the cognizant UMTA and TSC professionals, the contractor should indicate the value of d or δ selected for each measure to be collected, and should explain the rationale for choosing the particular value in terms of the cost-benefit considerations discussed above.

4. DATA COLLECTION

Once the minimum sample size for each stratification category of each sampled measure has been determined using the appropriate formula and the above three prescribed input factors, the data collection phase can be implemented. As was mentioned above, the contractor should apply a prudent expansion factor to the minimum sample size to obtain a target sample size. As better insight is obtained on the effectiveness of these project sampling plans, guidelines regarding sample expansion factors will be provided.

Field observations should be scheduled for a sufficient number of days to collect the target quantity of sample units. In most cases, the scheduling of data collection

will present no particular problems: the required number of "representative" days can be designated, as well as alternate dates to be used in the event of unusual weather conditions or other atypical occurrences on the planned dates. However, there may arise a situation where the day-to-day variability is known or suspected to be significant in relation to the variability within a day. In this case, arbitrary spreading of the data collection phase over several consecutive days may adversely affect the inferences to be made. Depending upon the project objectives, it may be more appropriate to schedule data collection for consecutive weeks on a particular day of the week (the most representative day).*

5. ANALYSIS METHODS

Since numerous statistical methods are available, the balance of this Appendix discusses a family of statistical techniques which will be appropriate for project analyses. The measures which will be collected and utilized to assess achievements of project objectives can be classified as discrete or continuous. A discrete measure is one which can assume only a fixed and known set of values. Examples of such measures would be counts of numbers of vehicles and passengers, responses to qualitative questions and classifications of survey responses into categories such as yes/no. Continuous measures may assume (in theory) an infinite set of values. The accuracy of these measures is constrained only by instruments used in collecting the data and the errors inherent in the data collection methodology. Examples of continuous measures are travel time and vehicle speeds.

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*The preceding discussion deals with day-to-day variability with a known pattern. In the unusual situation of day-to-day variability which exceeds within-day variability and does not follow a particular pattern, the target sample size must be calculated according to different procedures, which give a number of sample days as well as a number of samples per day. A. Hald, Statistical Theory with Engineering Applications, John Wiley and Sons, Inc., New York, 1952, Section 17.4 gives procedures which could be used in dealing with this situation.

Depending on the type of measure being collected, one or more of the following statistics will be obtained:

(1) Averages (mean values)
(2) Standard deviations (variances)
(3) Ratios, proportions
(4) Ranges for the raw data
(5) Frequency distributions of the raw data.

In addition to these five basic statistics, recent experience on several demonstration projects indicates the importance of the statistical measure known as the coefficient of variation, namely, the ratio of the standard deviation to the arithmetic mean. The contractor should be alert to the potential use of other statistical measures in his analysis of project data.

Confidence intervals will be computed for differences between means and proportions and for ratios of variability measures. The procedures for calculating confidence intervals on ratios of means and other ratios will not be given here, due to the complexity of the mathematical formulas.

Actual calculations of confidence intervals depend usually on four elements: the sample statistic being used to estimate the population parameter (defined above), some measure of variability associated with this statistic (e.g., the sample standard deviation), the confidence level, and the sample size.

Commonly used confidence levels have 99% and 95% probabilities associated with them. These correspond to α=.01 and α=.05. It is recommended that the contractor compute and report confidence interval estimates based on both values of α. This allows the decision-maker to assess both intervals and to determine which risk level is acceptable. (Note: For an α=.05, while there is a 95% chance that the method employed will contain the true value of the parameter being estimated, there is also a 5% chance that the intervals will not contain this true value).*

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*It should be noted that while the use of confidence intervals is required, the contractor may apply statistical tests of significance, where appropriate.

It should be noted that the sample size, n, which should be used in computing confidence intervals is the actual number of sample observations made, which, in most cases, will be different from the number originally planned.

Appropriate methods of analysis are now described in terms of discrete and continuous measures. It is implicit in any analyses performed using inferential statistical methods that the reasonableness of assumptions will be tested, for example, normality. If the data being collected can be classified as discrete, the following techniques may be used:

(1) Confidence intervals on a sample proportion to estimate the true population proportion. The appropriate techniques here will be to use either the binomial distribution or the normal distribution, depending primarily upon the sample size.

(2) Confidence intervals on differences between two proportions. In this situation the appropriate methodology is again to use the binomial distribution or normal distribution, depending on sample size.*

If the data element being collected during the demonstration can be classified as continuous, then appropriate methodologies which can be used are:

(1) Establishing confidence intervals on sample mean values to estimate population mean values. The appropriate methodology will involve Student's "t" distribution.

(2) Establishing confidence intervals on sample mean differences. The appropriate methodology will be to use the Student's "t" distribution.

(3) Determining whether differences observed from more than two sample mean values can be classified as significant. The appropriate methodology here would involve use of the F distribution and the

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*When appropriate, other methods, such as chi-square, may be used to assess significance of differences in discrete classifications where there are more than two alternatives.

analysis of variance, coupled with the application of appropriate linear contrasts techniques. (See C.H. McCall, "Linear Contrasts", Parts I, II, and III, Industrial Quality Control, Volumes XVII, Nos. 1,2, and 3, July, Aug., Sept., 1960.)

(4) Establishing confidence intervals on a single variance. The appropriate methodology will be chi-square.

(5) Establishing confidence intervals on ratios of variances. The appropriate methodology will be the F distribution.*

6. METHODOLOGY DOCUMENTATION

The contractor shall document and explain all considerations in data analysis and sample size selection for each measure including:

(1) How variability was estimated.

(2) Rationale for the desired level of precision chosen.

(3) How the final sampling plan was established to ensure that an adequate sample size would be available for analysis.

In addition, the method planned for performing all statistical calculations and tests should be documented by reference to the appropriate equations and tables in Natrella or other reliable sources.

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*For more than two variances, tests of significance rather than estimating confidence intervals may be appropriate.

7. REFERENCES

The following are considered to be excellent references for statistical methods:

(1) Natrella, M.G., Experimental Statistics, National Bureau of Standards Handbook 91, U.S. Government Printing Office, Washington, D.C., 1966.

(2) Hald, A., Statistical Theory with Engineering Applications, John Wiley and Sons, Inc., New York, 1952.

(3) Mace, A.E., Sample-Size Determination, Robert E. Krieger Publishing Company, Huntington, New York, 1974.

APPENDIX C

GLOSSARY

Access Point -- That point at which a transit vehicle can be boarded.

Access Time -- The time from leaving a point of origin to arriving at a point where an element of the transit system can be boarded.

Arterial -- A highway primarily for through traffic, usually on a continuous route.

Central Business District (CBD) -- Usually the downtown retail trade area of a city with a concentration of retail business offices, theaters, hotels, and service businesses. Generally an area of very high land valuation and heavy traffic flow.

Collected Measure -- A data element which is directly collected, either by measurement (e.g., vehicle travel time in minutes) or counting (e.g., number of vehicles).

Continuous Measure -- A data element which can, in theory, assume an infinite number of alternative values (e.g., travel times, vehicle speeds, distances). The accuracy of the recorded values for these measures is dependent, primarily, upon the instrument being used to collect the data.

Corridor -- A route or group of routes having similar travel characteristics and generally emanating from the CBD.

Derived Measure -- A data element which is calculated from basic measures (e.g., passenger miles per revenue mile).

Destination -- Terminal end of a trip or the point at which a trip terminates.

Discrete Measure -- A data element which can assume only a fixed number of alternative values (e.g., a yes/no response; classification by mode of travel).

Egress Point -- That point at which the passenger leaves the last transit vehicle to be used in going from his origin to his destination.

Egress Time -- The time it takes after leaving the egress point to arrive at the destination.

Elderly -- Generally accepted for evaluation purposes as persons 65 or over. It is noted, however, that the term elderly, or also seniors, is often applied to ages as low as 60, sometimes 55.

Evaluation Plan -- An evaluation plan sets the demonstration project frame of reference and, through project objectives, identifies the ways in which necessary data elements will be collected, processed, summarized, analyzed, and interpreted (it is recognized that modifications may be necessary as a project develops).

Experimental Design -- Similar to an evaluation plan, except that the data elements are obtained through a well controlled experimental situation. At UMTA, the phrase "experimental design plan" is sometimes used interchangeably with evaluation plan.

Handicapped -- A person who by reason of illness, injury, age, congenital malfunction, or other permanent or temporary incapacity or disability, is unable without special facilities or special planning or design to utilize mass transportation facilities as effectively as persons who are not so affected.

Headway -- The time lag between transit vehicles moving in the same direction on any given route.

Innovation -- An event or activity which is introduced within the project service area for purposes of assessing its effect on the transportation system and its impact on the community being served.

Low Mobility Groups -- Those who because of lack of opportunity or ability to use automobiles, or because the absence of adequate public transportation, or because of the lack of motivation or need, travel considerably less than others. Included are all of the transit dependent groups except, possibly, youth.

Measure -- A data element to be obtained during a demonstration project for purposes of evaluating project objectives.

Miles of Transit Route/Arterial Lanes -- Total route miles for transit system. Total lane miles of highway system.

Modal Split -- The separation of total person trips into various modes of travel.

Near Poor -- The term "near poor" refers to families just above the poverty line, including non-farm families. The near poor designation refers to families with incomes up to one-third above the incomes cited under the definition of poor. A near poor family of three would have an annual income of $4,230 to $5,640.

Origin -- The beginning of a trip or the zone in which a trip begins.

Passenger Trip -- The movement of a person in a vehicle between two points separated in space for a purpose other than solely continuing that movement.

Peak Hour -- That hour period during which the maximum amount of travel occurs (e.g., a morning and afternoon peak).

Peak Period -- That time period, usually longer than an hour, during which the maximum amount of travel occurs (e.g., an A.M. and a P.M. peak).

Poor -- A poor person is one who is a member of a poor family. The definition of a poor or "economically disadvantaged family" as defined by the U.S. Department of Labor is:

Family Size	Annual Income
1	$2590
2	3410
3	4230
4	5050
5	5870
6	6690

For each additional family member add $820

Because of differing transportation needs, a distinction is made between poor persons in the labor force and outside the labor force.

Project Service Area -- That geographic region from which potential customers for the transit system can be drawn.

Revenue Miles -- Sum, for each vehicle type in a transportation system, of the mileage over which revenue can be generated.

Route -- A fixed path traversed by a transit vehicle in accordance with a pre-determined schedule.

Run -- One transit vehicle trip in one direction from the beginning of a route to the end of it. When a transit vehicle makes a round trip on one route, it has completed two runs.

Screenline -- An imaginary line dividing the study area (demonstration area) into two parts for purposes of analysis.

Seating Capacity -- Total number of seats available on an operating transit vehicle.

Transit Dependent Persons -- Those who because of age, income, or physical/mental incapabilities must rely on public transportation, e.g., do not have use of automobiles except as passengers. Included are the elderly, handicapped, youth and poor (unemployed as well as non-members of the labor force).

Trip -- A person or vehicle movement which begins at the origin at the start time, and ends at the destination at the arrival time and is conducted for a specific purpose.

Unemployed -- Persons who are members of the labor force and who are registered as seeking a job. The labor force is the

sum total of all employed persons plus all persons registered as unemployed. The unemployed are further separated into frictional unemployed (persons who are in the process of changing jobs where such jobs are available), demand unemployed (the excess of trained workers over available jobs), and chronic or hard-core unemployed (individuals who have been unemployed for 16 weeks or more and who have obsolete or non-usable skills or who are systematically precluded from employment because of some feature of their being, e.g., their age, physical capability, language capability, etc.).

Vehicle Count -- The total number of vehicles in operation as detected by a vehicle count for each category.

Vehicle Fleet -- The total number of vehicles owned or being used under a purchase lease, related parties lease, or a true lease.

Vehicle Miles -- Sum for each vehicle type in a transportation system of the total mileage placed on the vehicle type during the reporting period. Can be classified into in-service (revenue) and non-service (non-revenue) vehicle miles.

Vehicle Trip -- A vehicle movement which begins at a specific start point and ends at a specific destination, said trip being for the purposes of revenue generation (see trip).

Youth -- For evaluation purposes persons who are 17 or under, based on the trend of state legislatures to designate age 18 as the age of adulthood or majority. Most evaluations will deal with the subgroup of ages 9 through 15 (and may refer to this subgroup as "youth"). The lower limit is an age when independent mobility, without parents, is expected. The upper limit is the earliest age when a driver's license is allowed.

APPENDIX D

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(2) The Cleveland Transit System/WABCO DC to AC Propulsion Demonstration Project

(3) The GT-IV Gas Turbine/Electric Commuter Car Demonstration Project

(4) The Light Rail Vehicle Demonstration Project

(5) The Rail Bus Demonstration Project

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